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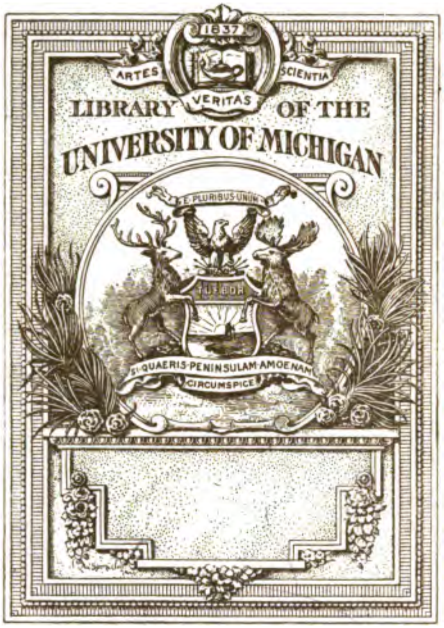
BUREAU OF FISHERIES
HUGH M. SMITH, Commissioner

FISHES AND FISHING IN SUNAPEE LAKE

By WILLIAM CONVERSE KENDALL
Scientific Assistant, United States Bureau of Fisheries

Bureau of Fisheries Document No. 783

WASHINGTON
GOVERNMENT PRINTING OFFICE
1913



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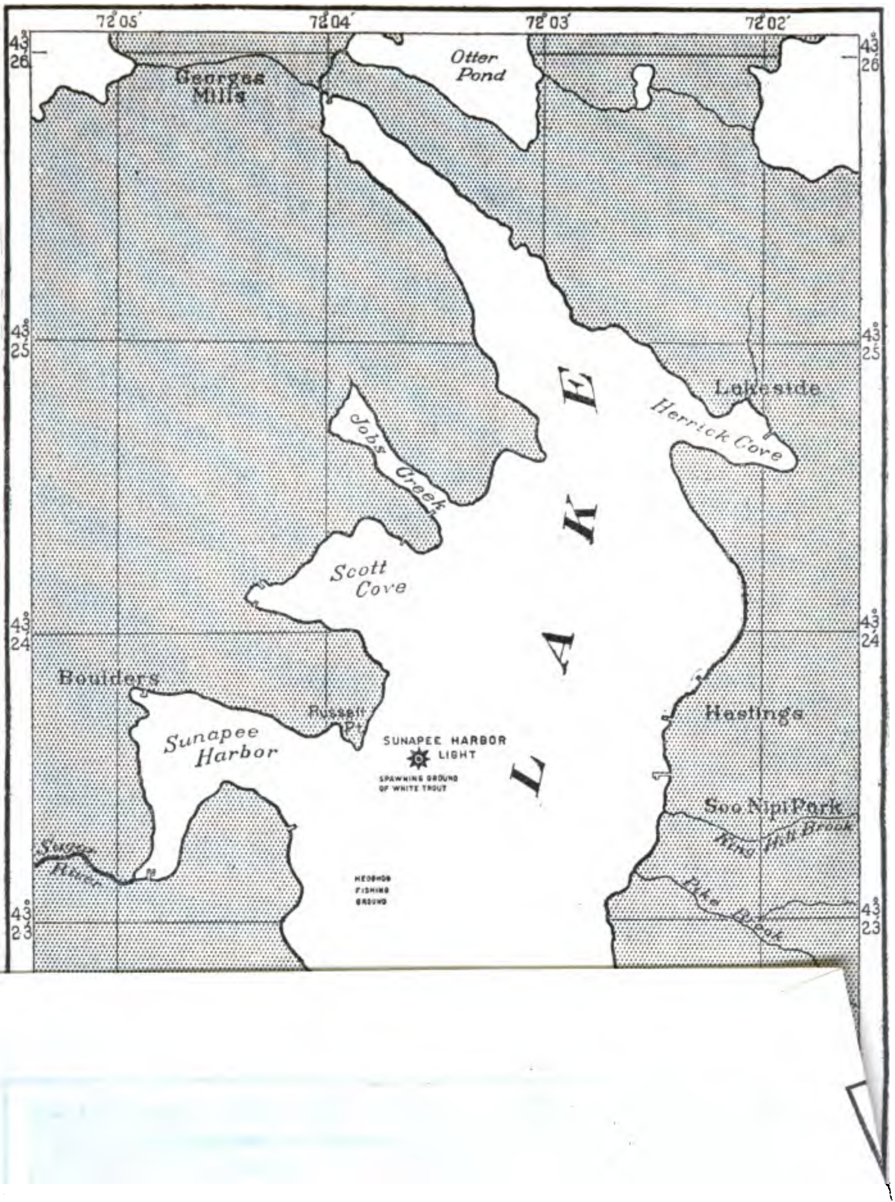
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Georges Mills
Otter Pond
Lakeside
Herrick Cove
Jobs Creek
Scott Cove
LAKE
Boulders
Sunapee Harbor
Russell Pt.
SUNAPEE HARBOR LIGHT
SPAWNING GROUND OF WHITE TROUT
HEDGHOG FISHING GROUND
Hastings
Soo Nipi Park
King Hill Brook
Pike Brook
Sugar River

FISHES AND FISHING IN SUNAPEE LAKE.

By WILLIAM CONVERSE KENDALL,
Scientific Assistant, United States Bureau of Fisheries.

PHYSICAL CONDITIONS IN THE LAKE.

Sunapee Lake is situated in the highlands of Sullivan County, New Hampshire, on the divide between the Merrimac and Connecticut River basins, at surface elevation of 1,091 feet above the level of the sea. It is surrounded by low mountains, highest on the west of the lake, the loftiest being Sunapee Mountain on the southwest side of the southern end, with its highest peak 2,743 feet above sea level. The lake is bordered at its northern half by the townships of New London on the east and Sunapee on the west, the dividing line between these running southward through the lake, and the latter extending to the upper end of "The Narrows," a little over a mile farther south than New London. The remainder of the lake is comprised in the township of Newbury. The principal villages of post-office importance are Newbury, at the extreme lower end of the lake, and Sunapee Harbor, at the head of the outlet. The Claremont division of the Boston & Maine Railroad has an all-the-year station at Newbury and a summer station at Lake Sunapee, the steamboat landing being 1 mile distant on the west side of the lower end of the lake.

A greater part of the shore is occupied by summer residences and hotels, and there are some considerable colonies or villages.

Sunapee Lake is but a little over 8 miles long following the course of the lake (although it is reputed to be 9), and its greatest width from Soo-Nipi Park pier directly west to Russell Point, which marks the upper outer end of Sunapee Harbor, is 1¼ miles.

From the mouth of King Hill Brook to "The Hedgehog," just south of the entrance to Sunapee Harbor, in a slightly southward course, it is just about 1½ miles, and disregarding the islands, from the mouth of Blodgett Brook in Blodgett Cove directly west to the head of Fishers Bay it is 1.8 miles. From Soo-Nipi Park pier shore end directly west to Boulders in Sunapee Harbor it is 2.1 miles, and continuing south to Sunapee Harbor landing it is six-tenths of a mile farther, but the distance by boat from Soo-nipi Park to Sunapee Harbor landing is 2¼ miles. From Hastings on the east side to head of Gardner Bay (Scotts Cove) it is nearly 2 miles. From Georges Mills southwest to inner end of Herricks Cove, just below Lakeside, it is 2.3 miles in a direct line.

Dunnings Point marks the western outer end of what might be considered a deep cove extending from the main lake northwestward to Georges Mills, a distance of 1.6 miles. Some seven-tenths of a mile below Dunnings Point is another point marking the upper or north side of the entrance to Jobs Creek, a narrow cove extending about seven-tenths of a mile inland northwestward, and only about one-tenth of a mile wide at the entrance, although widening up some at the inner end.

Scotts Cove is a rather wide, deep bay.

The lake may be considered to consist of two expansions connected by "The Narrows," the larger one being the northern expansion and the smaller the southern. The narrowest part of "The Narrows" lies between Woodclyffe on the west side and Rowes Landing on the east, a distance of about three-tenths of a mile, and at a distance of about 2½ miles from Newbury.

The southern end of the northern expansion is somewhat broken up by islands of various sizes, the largest of which is Great Island, which limits the steamer channel on the west side. The island is nearly one-half mile long by two-tenths wide, its southern end only something less than two-tenths of a mile removed from the mainland on the east side of the lake. Fishers Bay, directly west of this island, is shallow, and the space between the island interrupted by reefs. The real northern expansion may be considered to lie at the north of Birch Point on the west and Echo Point (Cressy's) on the southeast (the southern point of the outer end of Blodgetts Cove). Below The Narrows the widest part of the lake is between the outlet of Spectacle Pond (Sunapee Brook), a short distance above Edgemont, and the east shore, a distance of about nine-tenths of a mile.

The shores of the southern expansion are mainly rocky on both sides, there being a small sand beach at Newbury and muddy shores for a short distance at the mouth of Sucker Brook in Fishers Bay. On the east side the water is rather shoal and strewn with bowlders and heaps of bowlders locally known as reefs. The west side is fairly deep except in coves.

Above The Narrows, as previously mentioned, are a number of islands, and there are numerous bowlders and reefs of bowlders which probably were once small islands, with navigable passages among them.

On the east side of the northern expansion are extensive sandy beaches, forming sandy shoals for considerable though varying distances out into the lake, on the outer edge of which there is usually a rather abrupt descent into deep water.

The principal beaches, in order from the south northward, are: One extending from near Cressys Point on the south side of Blodgetts Cove to the mouth of Blodgett Brook and a little way on the north side of the cove. The shores are then rocky for about a mile to the "Owls Nest," just below the mouth of Pike Brook. Thence a beach extends to Hastings above Soo-Nipi Park with occasional short interruptions of rocky shore, especially at points. From Hastings to Georges Mills the shores vary in character, but are mainly rocky with outlying shoal water with sandy bottom.

The water on the west side of the expansion from below Dunnings Point at the entrance to Georges Mills Cove or Bay is comparatively deep and the shores are mainly rocky, as obtains even in some of the coves, such as Jobs Creek and Scotts Cove (Gardners Bay).

A large cove known as Sunapee Harbor, previously mentioned, situated about two-thirds the distance, on the west shore, from Newbury to Georges Mills, is the immediate origin of Sugar River, the outlet of Sunapee Lake, which debouches into the Connecticut River near Acutneyville post office, in the township of Claremont.

At the entrance to Sunapee Harbor are two or more rather extensive reefs of bowlders, contiguous to deep water, which were perhaps once islands. The most extensive one has more or less sand bottom mixed with the bowlders, and will be mentioned again in connection with the fish of the lake.

Mr. Henry Allen Hancox, a civil engineer of Newbury, has thoroughly sounded and accurately platted the depths of the whole southern expansion and up as far as the islands above The Narrows. Mr. Hancox kindly gave the writer a blue-print map from which the following data were obtained:

The deepest water of the southern expansion covers an area of several acres, carrying from 65 to over 80 feet of water. It lies east of the mid-north and south line and is known as the Deep Waters Fishing Ground. The deepest water in The Narrows is about 41 feet, at the northern entrance, ranging to 20 feet near the southern end mid line of the lake, just a little north of a line drawn east from Brightwood Landing.

In the portion of the lake between The Narrows and the islands is generally deep water, which obtains to not a great distance from either shore, from about 30 to over 80 feet.

Among the islands there are passages carrying from 10 to 30 feet of water.

In the summer of 1910 the writer essayed to sound the northern expansion above the islands, but abandoned the attempt owing to the unavoidable unreliability of the positions and the fact that Mr. Hancox stated that he intended soon to complete this work by sounding and platting the remainder of the lake.

The few soundings taken by the writer, however, show that the deepest water is probably about in a line between "The Hedgehog" and "Owls Nest," where the depth is something over 100 feet, varying, of course, with the height of the lake.

The white trout and salmon summer fishing grounds are contiguous to the deepest places in the lake, the principal ones being, from the north southward, Scotts Cove, The Hedgehog, off Birch Point, and Split Rock.

At Scotts Cove the ground is but a short distance from the entrance, where the depth is about 80 feet. At The Hedgehog the ground extends from not over 100 yards from shore out one-fourth of a mile or so, the depth varying from 60 to 90 feet or more. Off Birch Point the ground covers an area of 2 or 3 acres, perhaps, with a general depth of about 80 to 90 feet. At Split Rock, which is more restricted in area, not far from shore the depth is generally about 50 to 70 feet.

As is usual with deep cold lakes with rocky shores, there is very little vegetation. On the sandy shoals there are patches of varying extent of chara, and it is on the chara bottom that black bass are caught when they are caught at all on the sandy bottoms.

In protected localities, such as shallow coves, there is a more or less prolific growth of one or more species of pondweed, pipewort, etc. In the lagoonlike dead water of the mouths of some of the brooks the purely aquatic vegetation consists mainly of bladderwort, with some pondweed and bur-reed.

The quicker portions of the larger brooks contain often prolific growths of moss (*Fontinalis*) and a good deal of water cress.

TRIBUTARIES.

The meagerness of the tributary water supply indicates that Sunapee Lake must be to a large extent spring fed. There are no large inflowing streams. The largest is a brook entering the head of the lake at Georges Mills, which discharges the waters of Otter Pond and ponds connected with it.

The streams of more or less importance on the east shore, enumerated in order from Georges Mills southward to Newbury are: Two very small brooks entering Herrick Cove, one above and one below Lakeside; a very small one a short distance above Hastings; King Hill Brook, entering the lake at Soo-Nipi Park; Pike Brook, a short distance below this; Blodgett Brook and Newbury Beach Brook. In the same order on the west side are: Jobs Creek Brook; a diminutive brooklet entering Scotts Cove; one entering the north side of Sunapee Harbor; Sucker Brook, flowing into Fishers Bay; and Sunapee Mountain Brook, entering the lake above Edgemont. All are small brooks and some of them entirely dry during the summer, as they were

PLATE II.

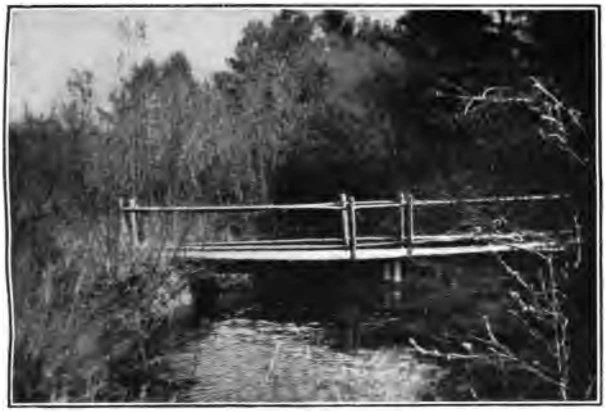
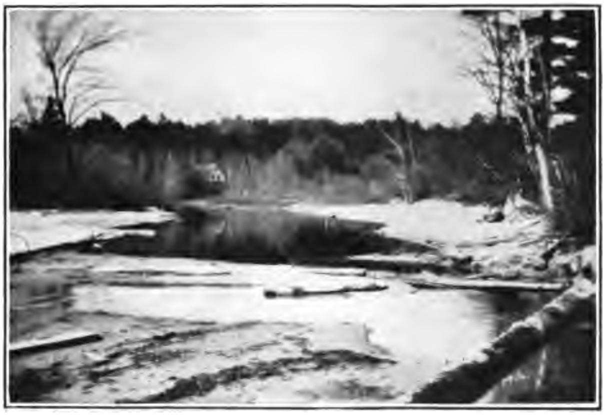


Fig. 1.—Upper bridge, above deadwater.

Fig. 2.—Deadwater.



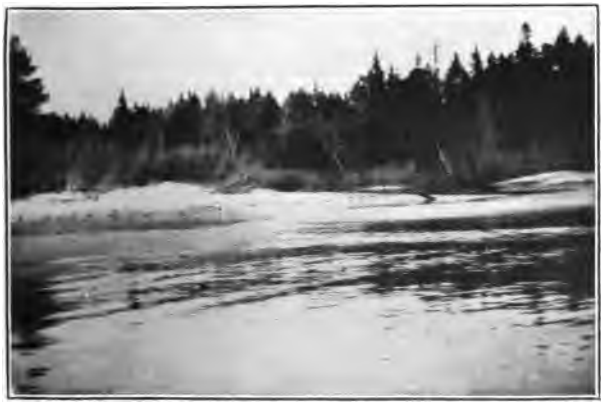


Fig. 3.—Mouth of brook.

KING HILL BROOK, LATTER PART OF APRIL, 1910.

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in 1910 and 1911. In the spring there is sufficient water in some of those that later become dry to permit smelts to ascend, which they do in enormous numbers.

All of these brooks were examined by the Bureau of Fisheries parties, but particular attention was paid to those which evidently had the most important bearing on the ecology of the lake, especially those which were natural trout brooks and have afforded in times past spawning grounds for trout, and still are the best smelt-breeding brooks, namely, King Hill, Pike, and Blodgett Brooks. These waters were studied very thoroughly in regard to their suitability for receiving the plants of young salmonids, and Sunapee Mountain Brook also was examined.

The ponds that empty their waters through Otter Brook into Sunapee Lake are: Baptist Pond, of irregular triangular shape, the apex southeastward at the outlet, seven-tenths of a mile in greatest length and about four-tenths in greatest width. It empties into Otter Pond through a stream about eight-tenths of a mile in a straight line. A small pond (McAlvins), about three-twentieths by two-twentieths of a mile, lies at the northeastward of Baptist Pond about seven-tenths of a mile distant in a straight line, but the outlet connecting it with Baptist Pond is considerably longer, owing to its irregular course. Besides this outlet tributary to Baptist Pond, which has two or more branches, there is a bog stream with a small pondlike expansion flowing into the northwest angle of Baptist Pond.

Star Lake, with two short inlets at its upper or northwestern end and a more considerable stream joining the lake near its southeastern outlet end, is situated at an altitude of 1,286 feet almost due north about 2 miles in a direct line from Otter Pond. It is about seven-tenths by five-twentieths of a mile in longest axes. Its outlet has numerous small branch brooks, and after flowing southeast a short distance turns southwestward, entering Otter Pond through a bog at its upper northwestern side. All of these are in the township of Springfield.

Little Sunapee Lake (Twin Lakes) lies almost directly east of Otter Pond at an altitude of 1,217 feet, mostly in the township of New London, but a small portion being in Springfield. In a straight line from Otter Pond to the foot of the lake it is only eight-tenths of a mile, with a drop of 92 feet. This lake is really only one lake divided about midway by a long, narrow peninsula extending from the northward side nearly across the lake; whence "Twin Lakes." The lake extends about 1.7 miles in northeasterly to southwesterly direction and is about seven-tenths of a mile wide along the previously mentioned peninsula to the opposite or south side of the lake. The lake is elliptical, though somewhat irregular in shape, disregarding the peninsula. Its principal inlet is Morgan Pond Brook; the headwaters of which is Morgan Pond, about 2½ miles in direct line north of Twin Lake. The brook flows almost directly east from Morgan Pond for a short distance, thence turns and flows in an irregular course, but generally southward. Morgan Pond, if it were not for coves, etc., would be practically circular in shape, about three-tenths of a mile in diameter. It is situated in the township of Springfield at an altitude of 464 feet above Twin Lakes, or 1,681 feet above sea level.

About 1.1 miles in a straight line up Morgan Brook there is a small expansion into which flows a brook from the northwestward, at the head of which is a small irregular triangular pond, about seven-twentieths by four-twentieths of a mile in dimensions, the base of which is at the eastward and the outlet of which leaves the northern basal angle and flows a short distance northeastward before turning to the southwestward. In a straight line from Morgan Brook this pond is about six-tenths of a mile distant.

Twin Lakes discharges its water westward into Otter Pond. In a distance of four-tenths of a mile from Twin Lakes the stream has a fall of 49 feet, emptying into a small pond on an expansion of crescentic shape approximately four-tenths of a mile long, following the curve, and having an extreme width of one-tenth mile. In the remaining distance of three-tenths of a mile in a direct line northwestward to Otter Pond the fall is 43 feet.

The small village of Otterville is situated near the expansion just mentioned.

Otter Pond, at an elevation of 1,125 feet above the level of the sea, is situated two-tenths of a mile in a straight line from the extreme head of Sunapee Lake at Georges Mills, following the course of the outlet, which has a drop in that distance of 34 feet. The greatest descent is, however, in a much shorter distance, i. e., from the dam at Georges Mills. Otter Pond in its long axis extends 1.1 miles northwest to southeast, and disregarding the outlet cove about midway of its westward side is about one-half mile wide in the widest place. Outlet Cove, extending approximately east and west, is about two-tenths of a mile long.

Near the entrance to the outlet cove in Otter Pond, in 18 feet of water, the temperature at bottom was 64°, at surface 67°.

A very small brook at Georges Mills enters the little dead water into which Otter Brook flows a short distance northwestward of Otter Brook. It was dry August 1, 1911. The temperature on the same date at the mouth of Otter Brook was 67°. This small brook is shown in Hancox's map as the outlet of Ledge Pond, but on the United States Geological Survey topographical map the principal outlet of the pond is Ledge Pond Brook, whose waters ultimately reach Sugar River through the outlet of Long Pond not far above Newport. On the same map, however, the previously mentioned little brook is faintly indicated as taking its rise in the same pond. Ledge Pond is irregularly elliptical in shape, nearly four-fifths of a mile in length and seven-twentieths of a mile in greatest width. It contains a number of small islands and is at an elevation of 1,306 feet above the sea.

A small brook entering the east side of Georges Mills Bay was entirely dry on August 18, 1910. But in April it was frequented by smelts and many bushels were dipped there. It is formed by two branches with bottom of coarse rocks or small bowlders above a stone bridge a few yards from the lake. Below the bridge the water of the lake extended nearly to the bridge. The smelts were caught below the bridge, as it is narrow and afforded the most favorable location for dipping, and the brook above is bordered and overhung with a tangle of alders and clematis vines.

The two brooks entering Herrick Cove seem to be fed by no permanent springs and were practically dry in the summer. It could not be learned that smelts ascended either of them, and it is doubtful if they do in this rather shallow cove, as the mouths of the brooks are so far removed from deep water.

King Hill Brook rises in the neighborhood of King Hill, from which it takes its name, and flows eastward through meadows and woodland and empties into Sunapee Lake at Soo-Nipi Park. Throughout its course the beds consist of sand and rocks. Here and there are deep pools with overhanging banks, long shallow expanses of sandy bottom, pebbly ripples, and bowlder-strewn reaches. In the lower part of its course to within a couple of hundred yards or so of the lake the country is entirely wooded, mainly with white and red pines with an admixture of various deciduous trees. Near the lake the brook is bordered by an alder growth for a short distance, thence sluggishly flows through a bushy and grassy boggy place, cleared somewhat, for the distance previously mentioned. Here the brook is much wider, some 40 or 50 feet, the bottom being composed of sand more or less covered with silt, sticks, and dead leaves. The entrance to the lake, excepting during the high water of spring, is usually obstructed by the sand beach, due to the prevailing westerly winds.

This brook in the summer of 1910 was very low and in 1911 almost dry until the latter part of July, when some heavy rains raised the water. It is a spring-fed brook, but the springs are so few and small that they do not supply sufficient water to maintain a permanent flow in the brook, although there are always pools of fairly cool water in which trout, minnows, and suckers congregate during the hot dry summer months. While the "dead water" is never entirely dry in midsummer, it becomes so heated, lying open to the sun's rays, that only such fishes as endure very warm water are found in it, and only occasionally one of them. On September 14, 1910, in Soo-Nipi Park, the brook was entirely dry above the dead water except in a few isolated pools. On July 29, 1911, the brook was very much higher than usual.

Pike Brook rises in Sutton about 2 miles in a straight line from Sunapee Lake. It is fed entirely by springs, seepage, surface water, and rainfall. At its upper end it is a mere rivulet lying through farm land, but the greater part of it flows through woodland and meadows. It empties into Sunapee Lake a few rods south of King Hill Brook at Soo-Nipi Park. It is evidently more copiously supplied by springs and seepage than is King Hill Brook, although about the same size, but perhaps longer. Yet in summer there are often places where the brook bed is dry; but the water evidently trickles through the sand and amongst the pebbles and rocks. At its lower end there is an extent of "dead water," perhaps 300 or more yards long and 40 or 50 feet wide in places, with a sandy bottom, but its banks are wooded. In summer, like King Hill Brook, and for the same reason, the mouth is obstructed by sand. There are three rather extensive meadows in its course, separated from each other by short tracts of woodland. The first lies about eight-tenths of a mile in a direct line from Sunapee Lake, another some distance farther up, and the other not far from the head of the brook. The first one is the longest and in it are deep pools with sandy bottom; in fact the bottom is sandy in the pools of all the meadows. The meadows are grassy with only occasional clumps of bushes on the brook's brim. The most extensive woodland is below the first meadow, mainly in Soo-Nipi Park. Through the woodlands, while there are some small swampy areas, the brook flows mostly over a bed of sand and gravel and through reaches of bowlders. There are the usual long shallow and occasional deep pools, as well as ripples and miniature rapids, especially in high water. The brook in its quicker portions has an abundant growth of moss (*Fontinalis*), and water cress is common.

In the dead water the vegetation consists mainly of bladderwort, floating bur-reed, yellow pond lilies, some water hemlock, and St. John's-wort. The water of Pike Brook in the wooded sections is always cool, but in the open meadows it becomes rather warm in summer.

Blodgett Brook is represented on the United States Geological Survey topographical map as a single brook having its source in Chalk Pond. Chalk Pond is situated in the township of Newbury, about 2 miles in a direct line from Blodgetts Landing in a southeasterly direction, at an elevation above the sea of something over 1,200 feet. It is slightly and irregularly crescentic in shape, about four-tenths of a mile long by three-twentieths of a mile in greatest width. There are

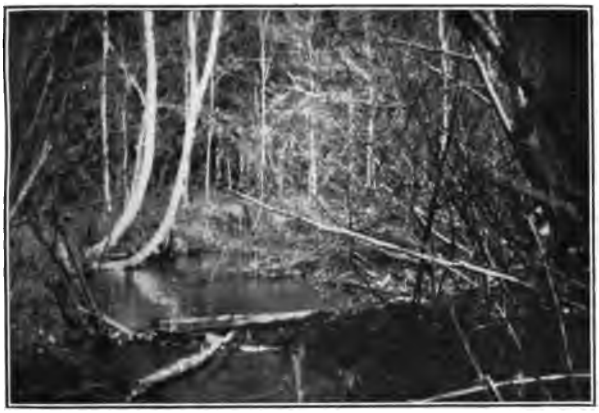

Fig. 1.—A woodland pool.

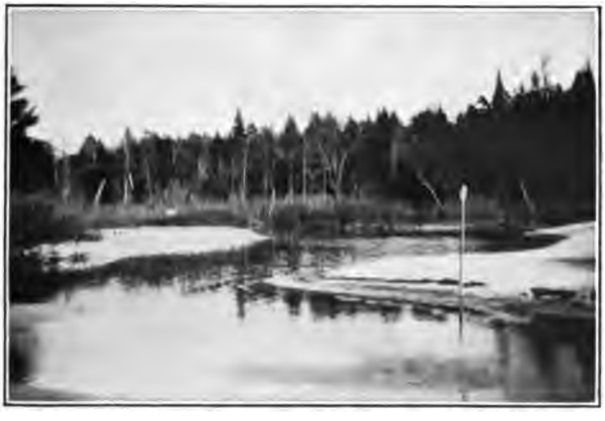

Fig. 2.—Deadwater.

PIKE BROOK, SPRING CONDITIONS, LAST OF APRIL, 1910.

practically two small streams which unite just above the bridge not far from the lake at Blodgetts Landing. The north branch is locally known as "Big Brook" and the south branch as "Little Brook." Big Brook is the outlet of Chalk Pond. Big Brook was explored only to the Newbury road, about seven-twentieths of a mile from the lake at its mouth, which is all the way through woodland, and some portions, especially a short distance below the road, are a tangle of alders and vines. This branch was explored two or more times, and there was always some water in the brook, even above the road, although it was dry in many places below during the summer. Below the road it is entirely a sandy, rocky, and gravelly bottomed brook to the bridge, not over 5 or 6 feet wide in any place, and in some places so narrow that it can be stepped across. This statement pertains to the summer conditions. In the spring there is a considerable body of water flowing in it, as was seen in April, 1910, and as evinced by the extent of the dry bed. While in the spring there seemed to be more water flowing in it than in Pike Brook, due perhaps to the Chalk Pond Reservoir, in the summer Pike Brook carries far more water.

About three-twentieths of a mile up this branch is an immense stone wall called "The dam," under which is a very small culvert, through which the small brook flows. Below and near the dam were moss-grown ledges over which earlier in the season must have been a forceful waterfall.

Little Brook, which in the spring carries much less water than the other, appears to rise only a short distance from the Newbury road, in an open field. During the summer it has more water and there are deeper pools. It is evidently fed by more or larger springs. At its upper end it consisted of two short branches, one of which in midsummer consisted of detached pools of spring water; the other was absolutely dry. The entire course of this branch from the fork just mentioned to its junction with Big Brook is through woodland, and it has a bottom of sand, gravel, and some bowlders, like Big Brook. Both branches naturally fluctuate in height of water with rainfall and dry weather. In both branches there are frequent pools that are never dry, and in both in a dry season there are portions of the bottom that are entirely dry at the surface, although water doubtless trickles through to some extent. The pools, however, in Little Brook are larger and deeper, and the temperature was constantly slightly lower than in Big Brook.

The brooks, especially in the spring-fed pools, have a more uniform temperature throughout the year than the shallow water of the lake. In such a pool near the hatchery at Pike Brook on April 28 and August 18 the temperature was 50° F., the highest point reached; on October 15, 45°; and November 2, 40°, the lowest point reached, a range of 10 degrees in about six months. The range of the temperature of the lake water near shore from April 28 to August 18 of the same year was over 30°.

The temperature of Pike Brook varied with the month and with the weather and according to the portion of the brook in which observations were made. But there was no great range of temperature, either of that taken in the same place or different places during the season or in different localities in the brook during the same day. During the summer, aside from the spring pools, the coolest part of the brook generally was where it flowed through the woods or Soo-Nipi Park, the warmest was in the dead water, and the next warmest in the meadows. On July 19 the shallow water of the first meadow registered 60° and at the bottom of a deep pool 59°. From just below the meadow, through the woods, excepting in spring-fed pools, down to Alaria Spring it was 58°; below this to and including a pool just above the dead water it was 57°. During August there was not much change from this condition, never over 2°. On the 18th the brook was constantly 57° through the woods, excepting the spring pools and the water near them, down to the broad shallow pools below the hatchery, where it rose to 58°, and the pool just above the dead water, where on July 19 it registered 57°, the temperature was 59°. The spring-fed pool near the hatchery has been referred to a number of times. It is a pool about 3 feet deep during the summer, situated a little to one side of the main current of the brook, where the water is shallow. On August 18 the temperature, as before stated, was 50° and the brook in the main current close by the pool was 55°. On the same date the dead water about halfway of its length registered 66° at the surface and 63° at bottom in 2 feet of water. At the head of the dead water in about the same depth the temperature was 60°.

Newbury Beach Brook is a small brook near the lake flowing through a small swamp. It does not seem to be a very desirable place in which to plant young salmonids. It was not learned that smelts ever ascend this brook.

Sunapee Mountain stream consists of two branches, one flowing down the side of Sunapee Mountain, steep and rocky, the other the outlet of Spectacle Pond. There is always water in the brook and always trout, but sometimes the brook is so dry that the trout are confined in detached pools and even some of these pools dry up. On one visit early in July many trout were removed from the pools and placed in deeper water below, whence they could descend to the lake. On July 26 there was more water in the brook.

Spectacle Pond is a small lake of very irregular shore line, which greatly modifies its otherwise general triangular shape, about six-tenths of a mile from apex to base and eleven-twentieths in greatest width near the base, which is the southwestward end. The pond is situated in a direct line from the widest part of the corner expansion of Sunapee Lake six-tenths of a mile to the westward, at an altitude of 1,113 feet, thus giving its outlet, which leaves Spectacle Pond from a deep cove at the eastern side of the apex of the triangle, flowing southwest and west, a fall of only 22 feet, passing through a practically level country

Mud Pond is practically a small diverticulum of Spectacle Pond. Sucker Brook entering Fishers Bay of Sunapee Lake is practically a bog brook throughout its extent.

The brook at Sunapee Harbor is also a small brook flowing over a rocky bed, mostly through woodland, to a short dead water at the lake. The brook is ascended by smelts in the spring, but on August 17, 1910, it was absolutely dry.

Jobs Creek Brook is another inconsiderable rivulet flowing into Jobs Creek, entirely dry in the dry season.

Sugar River, the outlet of Sunapee Lake, leaves the lake at Sunapee Harbor over a considerable descent formed by a natural steep ledge and bowlder fall and a dam. For some distance below the mill and factory it is a "rocked up" or walled raceway, the bottom of which is composed of coarse gravel and blue clay. The water flows swiftly over a steep descent for perhaps one-fourth of a mile or more from the lake; at the foot of this passage the stream expands into a shallow muddy dead water about 40 feet wide, more or less, according to height of water. Below this the river was not examined. On July 22 the water was very low with no current below the race. Temperature, 77° on July 27. The water was dirty, warm, and sluggish. In October the current was swift in the "race" and full of fine débris of various kinds.

NATIVE FISHES.

The fishes inhabiting Sunapee Lake and tributary waters prior to the fish cultural introductions, which began in 1867, so far as records thus far show, comprised an even dozen species. These are: Horn pout (*Ameiurus nebulosus*); sucker (*Catostomus commersonii*); chub (*Semotilus bullaris*); blackspot chub (*Semotilus atromaculatus*); redfin (*Notropis cornutus*); black-nose dace (*Rhinichthys atronasus*); "native trout" (*Salvelinus fontinalis*); "white trout" (*Salvelinus aureolus* [a]); eel (*Anguilla rostrata*); pickerel (*Esox reticulatus*); sunfish or "pumpkin seed" (*Lepomis auritus* [b]); perch (*Perca flavescens*).

Of these, in the lake itself, only the horn pout, sucker, white trout, and sunfish seem to be at all common. In the brooks the trout and black-nose dace are quite plentiful, but the presence of the former is due mainly to fish culture. There seems to be a great scarcity of the cyprinid fishes.

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[a] For reasons set forth in this paper in connection with this species, it is assumed that it is native to the lake.

[b] It is probable that another species (*Lepomis gibbosus*) occurs in some ponds connected with the lake, and the writer has been informed that it has been found in the lake; but in his observations, covering two seasons, he has seen none. There are published statements that the little fresh-water sculpin or "miller's thumb" (probably *Cottus gracilis*) was once common. It appears to be extinct now, or if present it is so scarce that none was observed in two seasons.

The pickerel is present in some numbers, but can not be called common. In Forest and Stream of March 18, 1886, Dr. J. D. Quackenbos states that in Sunapee Lake all fish excepting the pickerel attain an unusual weight: "Yellow perch, 2 pounds and upward; landlocked salmon, 12 pounds (seven years from the ovum); brook trout, 6 to 9 pounds; black bass, the unprecedented weight of 7½ pounds (2 pounds beyond the limit of the naturalist)."

The scarcity of pickerel and other fishes may be due to a number of causes, such as unseasonable and over fishing, abundance of enemies, epidemics, scarcity of food, etc. Scarcity of food acts in two ways, i. e., death from starvation and cannibalism. The small size of pickerel or any other fish may be due to the same causes. Excessive and unseasonable fishing, especially ice fishing, removes the large fish, and without sufficient food no fish will attain a large size. The habits of the pickerel are such that they seldom take the fish into deep water where the smelts occur.

The black bass and landlocked salmon were introduced fish, and Dr. Quackenbos's statement was made a long time after the introduction of smelts. The trout and perch are fish whose habits would take them where the smelts resort throughout the year. The large size of these fish, as well as of the salmon, can very well be ascribed to the smelt, and the cyprinids, which were doubtless once more common. The black bass has been diminishing in size for a number of years, probably owing to the disappearance of its once more plentiful cyprinid food. That the pickerel did not and does not attain a large size is doubtless due to the same thing.

INTRODUCED FISHES.

With the characteristic zeal and enthusiasm of the early fish culturists, the commissioners of New Hampshire began introducing into various waters of the State all kinds of food and game fishes that could be secured. Sunapee Lake was one of the first to receive attention of this kind, and, in the light of our present knowledge, it is possibly a question whether this indiscriminate introduction of alien species into waters whose original forms were all that could be desired in food and game qualities was not a mistake. It was and still is often done at the urgent request or instigation of some influential person or persons who have a commendable desire to improve the declining fishing but lack knowledge of the habits of the species proposed to be introduced and, consequently, of the possible results of the introduction. It has been, and still is, often the result that the remedy merely augmented the disease and the conditions became worse than before.

The writer is inclined to believe that where the trouble consists of diminishing numbers of native forms, the cause should be sought, as in the practice of medicine, and the malady treated accordingly. If a patient is suffering from loss of blood it is not wise to remove more blood or administer blood-destroying drugs.

In the case of Sunapee Lake the fishing was on the decline and the main cause, in time at least, became apparent, i. e., too much or unseasonable fishing. A very potent method of exterminating trout is by fishing through the ice, but that method becomes practically innocuous compared with the practice of taking trout from their spawning grounds, and history tells us that both of these practices were not only indulged in but abused in highest degree 40 years ago and even later.

The "native trout" once abounded in Sunapee Lake and attained a large size. But while little fishing was done in the spring and summer, it was a practice, not only of the inhabitants of the immediate shores but of those from distant towns, to repair to the brooks frequented by trout in the fall for spawning, and with dip nets and spears to catch the fish in great numbers.

Fishing through the ice was also done constantly. It is the habit of trout to congregate during the winter in certain places affording them the proper winter conditions. The inhabitants in years gone by found these places and the knowledge was handed down from parents to children. Naturally it did not take many generations to "bleed" the lake very seriously.

The cause being known, the remedy lay in combatting it and in the "infusion of new blood;" in other words, in prohibiting destructive methods of fishing and in propagating the trout. This was finally attempted, but while the trout was continuously propagated to some extent, nonindigenous fishes were introduced now and then up to the present time, practically offsetting the benefit.

The possible injurious effects of the introduction of nonindigenous fishes into a body of water may be brought about in at least two ways: First and chiefly, through the destruction of the native fishes by the introduced voracious forms, and second, but still important, the diminution of the food supply of the native forms by introduced species.

The first-mentioned factor was undoubtedly, years ago, to some extent at least, active in Sunapee Lake through the introduction of landlocked salmon, and, according to some statements, possibly by black bass. If the black bass is absolved of that stigma it certainly may be indicted on the second count.

The danger to the food supply of the fishes, however, was lessened by the wise introduction of smelt, which was the third species of non-native fish to be introduced. But this is claimed to have been detrimental to the fishing, many anglers averring that smelts afford such an abundant food supply that the game fish will not bite so readily and that the fly fishing has been ruined thereby.

The following is a list of the nonindigenous fishes in the order of the dates of first introduction:

Landlocked salmon, 1867.
Black bass, 1868.
Smelt, 1870.
Whitefish, 1871.
Wall-eyed pike, 1876.
Blueback trout, 1878.
Round whitefish, 1881 (?)
Loch Leven trout, 1888–9.
Brown trout, 1888–9 (?)
Rainbow trout, 1888–9.
Chinook salmon, 1904.
Grayling, 1906.
Silver salmon, 1909.
Lake trout (?) [a]

Of these the whitefish,[b] wall-eyed pike, blueback trout,[c] Loch Leven trout,[d] rainbow trout, silver salmon, and grayling have never been reported.

Omitting those which have not been authentically recorded, the list of species inhabiting Sunapee Lake in greater or lesser numbers will comprise 16, as follows: Hornpout, sucker, chub, blackspot chub, redfin, blacknose dace, chinook salmon, landlocked salmon, brown or Loch Leven trout, common trout, white trout, eel, pickerel, sunfish, black bass, perch. The status of each of these will be discussed under their respective headings.

There are various reasons why some of introduced species have never again been observed. The water may be unsuited to them, being too cold or too warm; there may be too many enemies, and the newcomers may have been all devoured by predaceous fishes; if they survive they may escape detection for a long time, or they may so closely resemble known species that they may not be recognized when caught. The latter is a very common occurrence, as evinced by the fact that when one of these forms has at last been recognized there were always those who remember to have caught one or more and to have thought them only variations of some known species.

THE ENTIRE FISH FAUNA.

HORNPOUT (*Ameiurus nebulosus*).

The hornpout is the only representative of the catfish family in New England, where it seldom attains a weight of over a pound. In Sunapee Lake it is said to be fairly common, and it seems to be indigenous.

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[a] There is no record of the introduction of this species, but some have been caught. Its occurrence is probably accidental, the young having become mixed with some other young salmonids.

[b] There are some vague traditions of whitefish having been taken in the lakes, but apparently none is there now. They could possibly be there and not be detected, but, by the methods of still fishing as practiced by the summer fishermen, if present, an occasional whitefish would probably be taken.

[c] Assuming that the white trout is an indigenous species and not the result of the plants of bluebacks. This question is discussed in another place in this report.

[d] "Loch Leven trout" of large size have been reported, but photograph and descriptions indicate that the supposed Loch Leven trout were brown trout.

It is occasionally caught by anglers while fishing for other fish in shallow water.

The favorite habitat of this fish being in shallow, muddy waters, and it being only very occasionally found elsewhere, there is no likelihood that it does much, if any, direct harm to the more desirable fishes, although it is almost omnivorous. The fish most liable to the attacks of the marauding hornpouts is the black bass when spawning in the shallow water, but even then the bass probably can take care of its nest to a great extent.

The only examples of this fish observed in the study of the lake were: On August 17, 1910, one about 10 inches long was caught off Cressy Point, and on August 17, 1911, the writer found in a "swash pool" near the mouth of Pike Brook eight young about 1⅛ inches long, and some smaller ones were taken in a fyke net in Pike Brook near the mouth at the inner or dead-water edge of the beach.

SUCKER (*Catostomus commersonii*).

The sucker is very common and attains a large size in Sunapee Lake.

When the water is sufficiently high in the spring to allow the suckers to get into the brooks, they run in in considerable numbers to spawn, and at that time many are speared by the residents, who esteem them highly as food. The run is usually from the last part of April to some time in May. In 1910 a very few suckers ascended Pike Brook. Nothing was learned regarding their presence in other brooks. The first to appear in Pike Brook were 3 males, 12¼, 16, and 17¼ inches long, respectively, which were speared on the night of April 16. Only one was quite ripe. No more were seen in April, but there was a small run reported in May.

The sucker deposits a large number of eggs and in the comparatively safe spawning beds many hatch and the young gradually work down into the dead waters, where some of them linger all summer and perhaps longer. On October 23, 1910, two suckers, respectively 12 and 14 inches long, were found in a pool in the beach at the mouth of Pike Brook. Their color was dark and brassy, indicating that they had probably come down from the dead water, and on November 3 a number from 5 to 14 inches long were taken with small trout that were descending from the brook into the lake. Some, however, while still quite young, enter the lake and occur in small schools along the shallow waters of the sandy beaches, and some may be hatched in the lake.

In April, 1910, the young suckers observed in Pike Brook averaged about 3 inches in length. In the same brook and in Blodgetts Brook in August the fish ranged from 1¼ to 2 inches long. But about the middle of August a lot of only ¾ to 1⅛ inches long were found in a pool in the beach left by the receding lake water. A small fyke net set at the dead-water end of Pike Brook channel through the beach, about the same time, took a considerable number, many from 1½ to 2 inches long, with some about 4 inches, which apparently had started for the lake.

Other fishes, such as black bass, perch, and pickerel, feed upon the young suckers, but the adult sucker is, on the other hand, very destructive to the eggs of other fishes, especially such as spawn in the lake. Suckers are always present on the spawning ground of the white trout in the fall and are taken in gill nets set for this trout by the fish culturists in spawning time. Some ranging from 6 to 17 inches were taken in the gill nets set for trout in shallow water near the mouth of Pike Brook.

CHUB (*Semotilus bullaris*).

The chub, here as in many other places known locally as dace, is the largest native species of the minnow family in eastern North America, in some waters attaining a weight of 2 or 3 pounds or more. It is also one of the commonest fishes of the Eastern States, but does not seem to be abundant in Sunapee Lake. Chubs were frequently taken in the gill nets set for white trout and salmon during October and November. The only adult individuals observed were some 12 and 13 inches long taken at that time, excepting one on August 18 that had been caught by some men fishing at "the banks." It was about 1 foot long and had red fins, which the men were using for bass bait.

Small chubs, in common with other small fishes of the family, are known as shiners and are esteemed as live bait. These occur in the brooks and were especially abundant in Pike Brook dead water. On August 18, 1910, a good many 2¼ to 2¾ inches long were taken with caddis larva bait at the lower end of the dead water.

Now and then one was seen farther up the brook, even in quick water, and one about 2 inches long was observed in the cool spring pool near the hatchery, but they seem generally to affect the warmer waters. It is not known that the young chub leaves the brooks and dead waters at any particular time or under any special conditions, but on August 17 and 18, 1911, a few 3 and 4 inches long were taken with other small fishes at the dead water end of Pike Brook channel through the beach, which indicated that they were possibly attempting to go to the lake.

Although the chub has toothless jaws and tongue, it is carnivorous, subsisting upon insects and other fishes to a large extent. The writer has seen chubs feeding upon and has found them gorged with young pickerel 3 and 4 inches long. While the chub is more or less destructive to other fishes and is, like the sucker, a spawn eater, it is too scarce now in Sunapee Lake to cause any alarm.

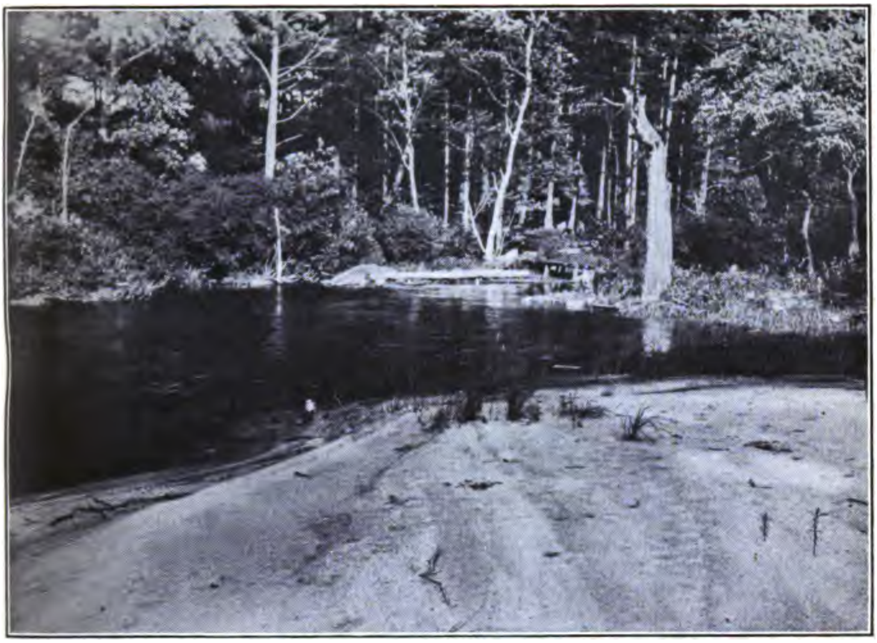

FIG. 1.—MOUTH OF BLODGETT BROOK IN AUGUST. DEADWATER JUST BELOW BRIDGE.

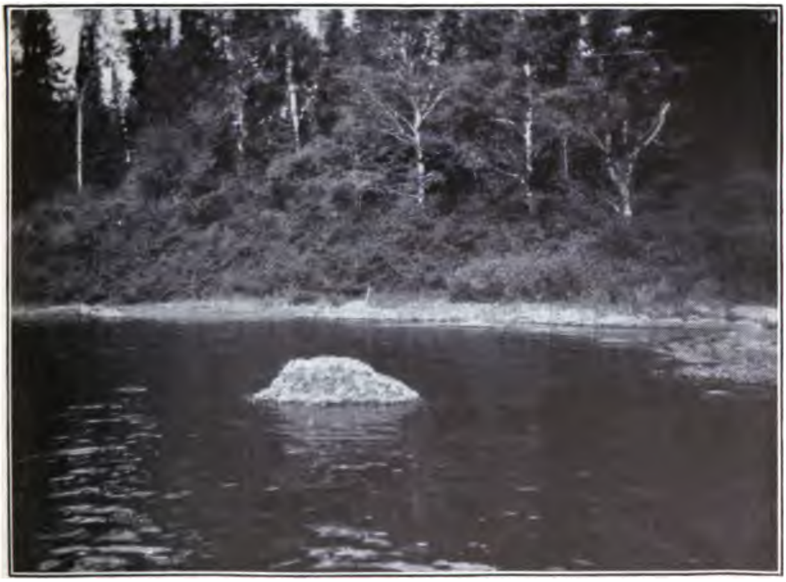

FIG. 2.—A CHUB'S NEST. PARTLY EXPOSED BY SUBSIDING WATERS.

(Photograph by courtesy of Dr. Alfred T. Wilson.)

The chub is very interesting in the curious habit of the male in breeding season of heaping up pebbles, which it conveys in its mouth to the spot chosen for the "nest" in which the female deposits her eggs. During the building usually no other fish is permitted to approach the nest, although in occasional instances one or more other males assist in the work of construction. The heap is often of remarkable size, especially in the waters of the far north, a cartload of pebbles composing it. The nests observed at Sunapee Lake were comparatively small, but the water having subsided they became quite conspicuous. On August 9, 1910, in the north branch of Blodgett Brook ("Big Brook") was found a chub's nest about 4 feet in diameter, but only a few inches high. Some of the pebbles composing it would weigh perhaps one-fourth of a pound, the coarser ones being on the upstream side, owing, doubtless, to a strong current when the nest was built or afterwards. In fact the current may have demolished the nest, which hypothesis would account for the wide area and lowness of the heap. There were other smaller and higher nests farther down the brook, one of them under the bridge. They were all dry at this time. On August 18 a chub's nest fully 5 feet in diameter and 1 foot high was found at the upper end of Pike Brook dead water.

BLACKSPOT CHUB (*Semotilus atromaculatus*).

This chub is known in the Connecticut Lakes region as "mud chub." It does not reach the size of the common chub, seldom, if ever, attaining more than 10 inches in length, and usually it is much smaller.

It is much darker in coloration than the chub and may otherwise be distinguished from it by the black spot near the base of the front of the dorsal fin. Owing to its darker color it is not so useful as bait as is the common chub. It subsists largely upon aquatic larvæ of insects, insects that have fallen upon the water, and occasionally young fish.

This chub is evidently not very common in Sunapee Lake or its tributaries, at least near the lake. The only specimen observed by the writer was collected in Pike Brook with smelts on the night of April 23, 1910. It was about 6 inches long.

The blackspot chub also builds "nests" of pebbles, but the heaps are much smaller than those of the common chub. On August 18, at the upper end of Pike Brook dead water, was found a small heap of little pebbles, very probably the nest of this species. The heap was about 8 inches in diameter.

REDFIN (*Notropis cornutus*).

The redfin, also known as redfin shiner and just shiner, reaches a length of 5 or 6 inches, but usually is not over 3 or 4 inches in length. The color of the pectoral fins and margins of the dorsal and anal of the male in breeding season gives it the name of "redfin," and it is a most beautiful fish at this season, reflecting all the hues of the rainbow. The red of the fins, however, often persists long after the breeding season. This fish is one of the most highly esteemed live baits, but, like other cyprinids, seems not to be common in Sunapee Lake.

The vertically elongated exposed portion of the scales of the body forward serve to distinguish this fish from all others of the family in New Hampshire.

The breeding season of the redfin is in the spring or early summer. The precise time of its breeding in Sunapee Lake was not ascertained, but on April 16, 1910, a number about 3 inches long, two of them with red fins, were taken in Pike Brook. The species seems to be common in Pike Brook dead water throughout the summer. On August 19, 1910, several specimens 3½ to 4 inches long were caught at the upper end of the dead water on caddis larva bait, and on August 19, 1911, several about 3 inches long were taken in the fyke net at the dead-water end of the channel through the beach.

BLACKNOSE DACE (*Rhinichthys atronasus*).

This is the smallest species of the minnow family found in this region. It is not commonly seen in the lake, but in brooks it is apparently abundant. It is easily recognized by the very fine, scarcely discernible scales and the intensely black stripe extending from the snout to base of the tail. It attains only 4 or 5 inches in length, and most of the individuals observed are somewhat smaller. It also is a good bait.

It subsists mainly upon the aquatic larvæ of insects and small insects that fall upon the water. It affords food for trout to some extent, but in the brooks it occupies the warmer portions in summer, where the trout are not at that time found.

Many from 1½ to 3 inches long were observed in Pike Brook on April 15, 1910, and on July 19 and August 15 many were seen in the same brook in the lower meadow.

PICKEREL (*Esox reticulatus*).

The pickerel is the only member of the pike family indigenous to New Hampshire waters. It is a well-known fish, by some highly esteemed, much maligned by others, being accused of all sorts of piscivorous atrocities. There is scarcely a body of water in which trout once lived and where pickerel now occurs that the depletion of the trout has not been ascribed to the pickerel. It undoubtedly eats other fishes, and there are few fishes that do not. But the habits of the pickerel are such that it is not nearly so detrimental to other fish life as some other species held in higher regard, and the pickerel in large bodies of water becomes still less harmful. It is not much of a wanderer. It does not rush about in marauding bands seeking what it may devour. It lies in wait and grabs what comes its way when it is inclined to feed, yet often schools of tempting shiners have been seen swimming unharmed in apparently dangerous proximity to big pickerels' heads. Pickerel feeding will take any moving object within reach, young of their own kind not excepted. Young pickerel from 2½ to 3 or 4 inches long at Sunapee Lake were found subsisting almost wholly upon the aquatic larvæ of insects that occur so abundantly in the still or dead waters of the brooks.

While usually inhabiting the shallow, weedy coves and bays in the warmer months, large pickerel are often found about rocky shores and in deeper water. In winter, too, they congregate in deeper water, and it is owing to this fact that fishing through the ice so often depletes a lake or pond of pickerel.

The habit of pickerel of seeking shallow, weedy places is one which ordinarily makes for the safety of the deeper and cooler water denizens, but in some lakes, Sunapee, for instance, it becomes to some extent a disadvantage. Such congenial pickerel haunts are the dead waters at the mouths of inflowing streams, which streams are often natural trout nurseries and are frequently used in planting trout and salmon. When the trout and salmon descend toward the lake they often have to run the gauntlet of the waiting maws of the pickerel and doubtless many have been destroyed in that way.

The pickerel probably spawns in the dead waters of the brooks when possible, and the young remain in shallow water until they are of considerable size. While they are most frequently found in the shallowest waters and even some distance up the brooks, they probably seek these places mainly for self protection from other larger and voracious fishes rather than for food, which is more abundant in the still or dead waters. During 1910 and 1911 some young pickerel were seen throughout the season in Pike Brook dead water. In August the young were from 2⅜ to 3¼ inches long and all at the upper end of the dead water or in a pool a short distance above the dead water.

The smallest pickerel observed in the lake were two, each about 10 inches long, seen at Newberry in shallow water on rocky bottom, October 18. Other pickerel observed were one of about 2 pounds caught by trolling in July near Blodgetts Landing and several in October and November, 13 to 16 inches long, taken in gill nets near the mouth of Pike Brook. A 13-inch fish caught near the mouth of Pike

Brook bore marks as though a mink had bitten it. Its stomach contained the tail end, including the anal fin, of a half digested sucker. Judging from the fragment, the sucker must have been about 6 inches long.

The pickerel, however, while once quite abundant, is now comparatively scarce, and therefore is almost a negligible factor in trout and salmon destruction in Sunapee Lake. The reasons for this are those that obtain in the cases of scarcity of fish of any kind in any fresh waters. The waters are not especially suited to pickerel. There has been an increase in numbers of some of its existing enemies, there has been a reenforcement of others, and the lake has been excessively fished at times particularly advantageous to such fishing.

EEL (*Anguilla rostrata*).

The common eel does not seem to be very common in Sunapee Lake. It is so rarely taken by fishermen that but few know that it occurs there. It probably can now with great difficulty, if at all, gain access to the lake. The only one observed by the writer was caught on a "set line" with smelt bait at Curtis's pier, April, 1910. It was 28½ inches long. The stomach contained a lot of fine, brown, mud-like substance, the nature of which could not be determined.

The eel is very destructive to fish, especially small ones, and fish eggs. It attacks and attaches itself to spawning fish caught in gill nets and burrows into the body, eating the ovaries and eggs. It is fortunately so scarce that it need not be feared for the damage that it otherwise might do.

WHITEFISH (*Coregonus clupeaformis*).

The State report for 1871 says that 120,000 whitefish were hatched from eggs obtained at Missisquoi Bay, Lake Champlain, and planted in "Winnepiseogee" and Sunapee Lakes. The report for 1872 says that some 50,000 or 60,000 were hatched and the young divided between Winnipesaukee and Sunapee Lakes, and in 1873 it is reported that 150,000 were hatched and planted in the same lakes.

The whitefish has not been recognized in Sunapee, and it is doubtful whether it occurs there, although it might escape notice for many years. It was not until about 1901 that it was discovered to exist in Sebago Lake, Me., where it seems as though it must be indigenous, as there are no records of its ever having been introduced. Since its discovery there a good many specimens have been taken and recognized. It is a somewhat laterally compressed fish with very small, toothless, and tender mouth parts. It is the same fish that is indigenous to Lake Winnipesaukee, where it is known as "whiting." In some waters it attains a weight of 10 pounds or more. The majority, however, as caught, are much smaller.

It occasionally takes the hook baited with small fish, and sometimes rises with avidity to the artificial fly. It is an excellent food fish and one usually commanding a high price in the market.

The native whitefish of Maine and New Hampshire, whenever possible, ascend streams to spawn, in the last of October and in November, but the Great Lakes whitefish are not known to do this, perhaps because of the absence of suitable streams, or perhaps they have not been reported.

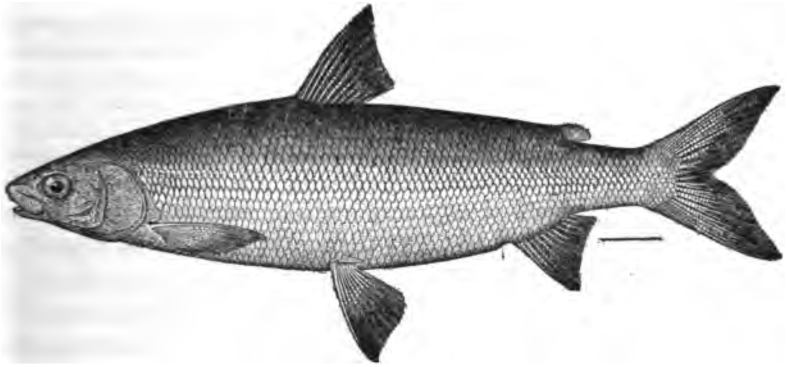

FIG. 1.—Whitefish.

The whitefish varies its diet considerably, its food consisting of insect larvæ, insects, and small fish such as young smelts, and, when obtainable, Crustacea and mollusks.

ROUND WHITEFISH (*Coregonus quadrilateralis*).

This fish occurs in many of the larger and deeper lakes of New England, northern New York, the Great Lakes, and to Alaska, Labrador, and the Arctic Circle. It attains a weight of 2 pounds or more, but usually is considerably smaller. Its principal food seems to consist of insects, insect larvæ occurring in the water, minute Crustacea, etc. It occasionally takes a baited hook and sometimes an artificial fly. In most New England waters, when possible, it ascends streams in the last of October and early November to spawn, at which time the males are covered with small pearly excrescences or so-called breeding tubercles (as is the case with nearly all of the species of whitefish), the significance of which is not positively known, but possibly by the male rubbing against the female they excite her to extrude her eggs.

It is a very good food fish but inferior to the preceding species. No advantage would be gained through its successful introduction into Sunapee Lake except by affording food for other fishes, unless net fishing were allowed, as it so seldom can be taken in any other way.

The round whitefish may be distinguished from the common whitefish by its more cylindrical or spindle-shaped form, smaller mouth, compressed and sharper snout, and more numerous scales. In the Connecticut Lakes it is known as "billfish."

In the Report of the Fish and Game Commissioners of New Hampshire, 1881, page 21, the following paragraph appears:

> WINNEPESAUKEE WHITEFISH, OR "SHAD-WAITER."
>
> This delicious fish is little known in the State, except to the inhabitants of the towns bordering on Lake Winnepesaukee, but is really one of the most valuable food fishes we have.
>
> It is a local variety of the celebrated whitefish of the Great Lakes, and is unsurpassed in its qualities as a table fish. It belongs to the same great family of Salmonidæ, and is now classed by Profs. Jordan and Milner as *Prosopium quadrilateralis*. We took at Weirs Village, last November, 60,000 eggs of this fish, one-half of which were sent to Massachusetts, and the remainder will be placed in Sunapee Lake. We believe that the propagation of this variety of fish should be followed up in future, and one or more of our largest lakes stocked annually with from 20,000 to 30,000 young fry. All experience goes to show that the larger the plant made the more likely it is to be successful.

No further mention is made of planting the fish in Sunapee Lake. While according to Dr. Prescott,[a] this fish, which he describes as new under the name of *Coregonus Nov-Angliæ*, is called "shad-waiter" at Winnepesaukee, and the common whitefish, which he also describes as new under the name of *Coregonus Neo-Hantoniensis*, is called "the whiting," there is some doubt whether this species and not the common whitefish is meant in the preceding quotation from the commissioners' report, since it is there stated that "it is a local variety of the celebrated whitefish of the Great Lakes."

Chinook Salmon (*Oncorhynchus tschawytscha*).

The chinook salmon is an inhabitant of Pacific waters, its geographical range extending from Alaska to the Ventura River in California, and northern China on the Asiatic coast. It is the salmon that made Columbia River famous and is by far the most valuable of its tribe. It attains the largest size of the five species belonging to the genus *Oncorhynchus* (hook-nose), individuals weighing over 100 pounds having been reported. It does not, however, average much, if any, over 20 pounds.

Habits.—Like other salmon, much of its life is spent in the sea, whence to breed it ascends fresh-water rivers, when possible to their utmost sources, sometimes more than 1,000 miles from the sea. The time of its runs and the spawning time varies in different rivers. In southern rivers there are spring runs and summer spawning, and later runs with fall spawning. The early runs ascend farthest up the river.

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[a] Descriptions of new species of fishes, from "Synopsis of the Fishes of the Winnipesseogee and its Connecting Waters," Am. Jour. Sci. and Arts, 1851, p. 342, by William Prescott, M. D., of Concord, N. H.

Farther north the runs are not so distinct and the spawning times not so widely separated. In Alaska, for instance, while there are indications of distinct runs, the process is practically continuous.

The young salmon are said to go to sea as soon as they can swim and eat. Their parents, like all other salmon of the genus *Oncorhynchus,* soon die, the species spawning but once in a lifetime. This is not a recently discovered, though a comparatively lately verified, fact. In Arctic Zoology, published in 1784, Pennant, deriving his information from an earlier work on Kamchatka, says:

> Every species of salmon dies in the same river or lake in which it is born, and to which it returns to spawn. In the third year male and female consort together and the latter deposits its spawn in a hole formed with its tail and fins in the sand, after which both sexes pine away and cease to live.

Pennant, however, evidently ascribes this phenomenon to starvation and attendant weakness and the consequent inability to reach the feeding grounds, and not to a decree of nature.

Young salmon subsist mainly upon insects.

It has been positively ascertained that in the sea the chinook does not, always at least, depart far from the coast, and that while in the sea and estuaries it feeds upon small fish such as herring, smelt, anchovies, etc., and its movements in the sea are doubtless to a great extent governed by its food supply. It is, however, apparently a rather indiscriminate feeder, taking not only almost any small fish, especially those that swim in schools, but free-swimming marine invertebrates, such as squid, shrimp, etc. Its voracity is graphically illustrated by J. Parker Whitney in an article descriptive of angling for chinook, in Monterey and Santa Cruz Bays, Cal., which appeared in Forest and Stream a number of years ago. He says:

> As I fought my salmon to gaff, my sinker was caught by another salmon as I was lifting it clear from the water to detach as usual from the boat side, and carried it off. This was within 6 feet of the boat and I plainly saw the rush, the open mouth, the strike, and the tear away. The sinker line fortunately broke, leaving my half-exhausted salmon on my hook line, which I afterwards safely brought in. Striking at the sinker is by no means rare with the salmon; this was the third I had had carried away. I have several times seen the salmon strike the sinker within 6 or 10 feet of the boat and strike at it several times in succession.
>
> There was no difficulty in following the school, although the later ruffled water made the break less conspicuous. The friendly shags, murrs, and gulls came for their harvest also, following up the salmon breaks for the demoralized anchovies.
>
> On the combing beach went the anchovies, the salmon, and birds, and more slowly my boat, impeded by the necessity of fighting the hooked salmon. But we followed on, finally into the jaws of the ground swell, where for half a mile in length on the sand beach the salmon held the anchovies for at least two hours. Many of the anchovies were driven upon the sand.

Acclimatization in eastern waters.—Attempts have been made to acclimate the chinook in many eastern waters. The earlier plants were made under the name of California salmon, later under the names of quinnat salmon and Pacific salmon. The latter, however, is not specific, there being four other species of this genus in Pacific waters. The best-known and appropriate names in the United States and Alaska are chinook salmon and king salmon, although it has several others of somewhat restricted local use.

This salmon has been planted in eastern waters, off and on, since 1873, and some placed in fresh-water lakes. The results of these plants have not been very encouraging, the most successful outcome being in Sunapee Lake.

The records of the capture of this species in any waters since its introduction are very meager. From those planted every year from 1874 to 1879 in Lake Michigan waters only two have been reported; June, 1879, one measuring over 20 inches in length, caught in Lake Michigan, and in November of the same year another measuring 10 inches in length, caught in Green Bay, Mich., were sent to the United States National Museum. From the report of the Fish Commissioners of New Hampshire for 1881, the following extracts are reprinted from an article by N. K. Fairbanks, entitled "Breeding California salmon in fresh water," referring to the results of introduction of the chinook into Geneva Lake, Wis.:

> Having all the requisites which I consider essential to the experiment, viz, pure deep water, a moderately sized lake, with room for range and exercise and plenty of food, I began in the spring of 1876 by depositing 25,000 California salmon which were hatched at the United States hatchery at Northville, Mich., by Frank N. Clark, and were sent to me by Prof. Baird, United States Fish Commissioner. The Wisconsin commission also put in about 15,000 shortly after.
>
> In April, 1877, I also procured from Prof. Baird about 25,000 and from the Wisconsin commission 25,000, and in the fall of 1877 I received from the United States commission 100,000 eggs from the McCloud River, which I hatched and put into the lake in the spring of 1878. I also deposited 200,000 in the spring of 1879, 100,000 last April, and 100,000 yearlings last October, making in all in round numbers 590,000, hatching count; deducting for losses from various causes, I estimate that I have placed in Geneva Lake half a million young California salmon in excellent condition.
>
> They began to make their appearance and attain considerable size very soon, and during the summer of 1878 there was an occasional one caught by parties who were fishing for bass. I had four sent me one day which weighed three-quarters of a pound each, and one of them went a trifle over a pound. In the summer of 1879, Mr. L. Z. Leiter, while trolling for bass, captured a very fine salmon which weighed 4½ pounds. Several others were taken during the summer, weighing 2 to 3 pounds each, all of which was reasonably encouraging; but not until the developments of the past summer have I felt that the experiment would prove a valuable one, when, on the afternoon of July 29 last, I was presented with a beautiful specimen which was 29½ inches long and 18 inches girth and weighed 12¾ pounds, and when I had it boiled and served for dinner and found it to be a delicious fish, then I felt certain that the salmon would grow to a respectable size and condition in fresh water, and that at least, so far as that fish and my dinner of that day went, it was no longer an unsuccessful experiment—there was a reality, the "substance of things hoped for," which did much to strengthen and build up my faith.
>
> In September they began to show themselves at the head of the lake near the mouth of a small creek having its source in a group of springs a mile back, which empties into the lake. Mr. William Welsher, who has charge of the hatchery and ponds there, discovered eight fine specimens one day splashing about in this creek. They were up the creek nearly a mile, and as far as they could get and were, of course, looking

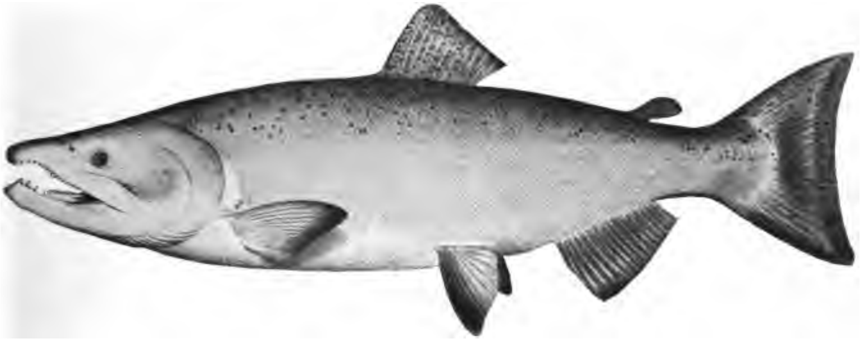

FIG. 1.—CHINOOK SALMON. BREEDING MALE.

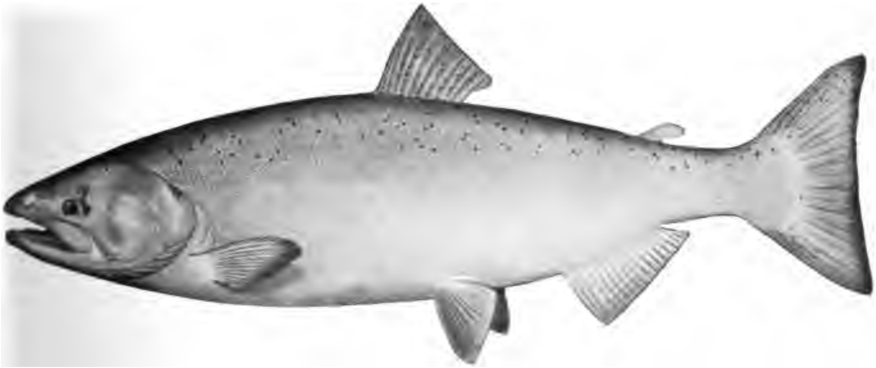

FIG. 2.—CHINOOK SALMON. BREEDING FEMALE.

for a spawning bed. The following day he captured a fine female in the creek, which was full of eggs and quite ripe. Those which he saw in the creek he estimated would weigh 8 to 10 pounds each. The one he caught weighed 8½ pounds, and one which he found up the creek a week later in shallow water, and which he picked up and threw into deep water, he estimated would weigh 10 pounds. He informed me that a month ago he saw a pair much larger than before mentioned, at the mouth of the creek, but they could not get over the little bar formed at the mouth. He estimated this pair would weigh 20 pounds each, and that the female might go up to 25 pounds. He also saw very decided indications of spawning nests in the gravel about the mouth of the creek, all of which facts satisfy me that the salmon will not only attain a large size but will also breed in fresh water. Unlike Brigham Young, they find they can be very good Mormons and increase and multiply without going to a salt lake.

Salmon were planted in Lake Ontario waters in 1879 and again in 1897 and 1898, but only one was ever reported. This fish, a ripe female, weighing 14 pounds, caught September 1, 1900, was sent by Livingston Stone from Cape Vincent to the United States Fish Commission.

No more were reported from anywhere until 1903, when the State Fish Commissioner of Maine wrote to the United States Fish Commissioner that quinnat salmon, some of which weighed as high as 16 pounds, were being caught in Pierce Pond, an affluent of the Kennebec River, in Somerset County, Me. An investigation of the subject revealed that the large fish supposed to be chinooks were landlocked salmon. Two years later, however, small fish of 1 or 1½ pounds in weight, stated to have been caught in Pierce Pond, were sent to the Academy of Sciences of Philadelphia and United States National Museum, and proved to be chinooks, but they were the result of plants subsequent to the one supposed to have been the origin of the alleged "quinnats" of 1903.

The first of this species to be planted in Sunapee Lake were 3,000 fingerlings hatched at the Laconia station in 1904. Though there are no definite records between 1904 and 1908, it has been stated that some fry have been planted every year since, and in the State commissioners' report for 1907 and 1908 it is stated that the commissioners for the last four years have planted fingerlings and yearlings of the Pacific salmon. There is also the indefinite record of 12,000 "salmon" fingerlings planted in Sunapee Lake in 1907. In the United States Bureau of Fisheries report for 1904 it is recorded that 100,000 eggs were sent to the Laconia station, and there are consecutive records from 1908 to 1910, inclusive, while the writer has been able to secure from the Division of Fish Culture, Bureau of Fisheries, a statement of the number planted in 1911. The published records and this statement show the following plants: 1904, 3,000 fingerlings; 1908, 40,000 fingerlings; 1909, 38,070 fingerlings; 1910, 51,200 fingerlings; 1911, 24,370 fingerlings and fry; total, 156,640.

Records of chinook salmon caught in Sunapee Lake.—The following records are far from complete, but they represent all the positively identified salmon that have been reported. George H. Graham, secretary of the Sunapee Lake Fishing Association, states[a] that during 1908 a few of these salmon were taken weighing from 2 to 4 pounds, during 1909 over 200 were taken, some weighing 8 pounds, and during 1910 from 400 to 500 were taken, some as large as 17 pounds. One angler, according to Mr. Graham, caught nine salmon that weighed 80 pounds, the largest two weighing 13½ pounds each. The banner year was 1910, the catch of 1911 falling far short of the catch of that year.

It can not be positively affirmed that all the fish reported as such were chinooks, but it is sure that the majority were, inasmuch as most of the anglers had learned to distinguish this species from the landlocked salmon. It is possible, however, that some "landlocked" were pronounced chinooks, and that possibly silver salmon may have been mistaken for chinooks, being more difficult to distinguish.

DATA REGARDING CHINOOKS CAUGHT IN SUNAPEE LAKE, AS AFFORDED BY ALL AVAILABLE RECORDS PRIOR TO 1910.

Date of capture.	Size.	Sex.	Remarks.
Aug. 28, 1906	5¾ pounds		First reported.
Apr. 28, 1908	24½ inches long	Male	Ripe.
August, 1908	11½ inches long		
Apr. 30, 1909	10 pounds		
May, 1909	15 inches long		
Aug. 14, 1909	5 pounds		
Nov. 8 to 12, 1909.		4 males and 1 female.	Taken by Bureau of Fisheries party. The female was immature but probably would have matured in 1910. An unsuccessful attempt was made to fertilize landlocked salmon eggs with chinook milt.

DATE OF CAPTURE AND WEIGHT OF 31 CHINOOK SALMON BROUGHT INTO BLODGETTS LANDING AND 15 BROUGHT INTO NEWBURY IN 1910.

Date.	Weight.	Date.	Weight.
BLODGETTS LANDING.		BLODGETTS LANDING—continued.	
	Pounds.		*Pounds.*
Apr. 22	9	June 28	8
24	8	30	10½
27	7	July 10	4
May 4	5	12	5
4	5	13	8¼
5	7½	25	10½
8	7½	26	7½
8	6½	NEWBURY.	
8	4	Apr. 17	2¾
24	8	17	4 1/16
27	8	17	4 3/16
28	7	17	2 1/16
29	8	17	5 5/16
30	6	17	4¾
June 4	3	24	6⅞
14	4½	May 4	3
14	4½	8	5½
14	4½	11	4¾
14	4½	June 3	6⅞
14	9	(?)	16
14	4	Aug. 2	7½
14	6	4	12
21	9⅛	11	16⅜
25	7¼		

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[a] Recreation, Apr., 1911, p. 187.

The preceding table records 46 chinooks taken during the season of 1910, averaging about 6.5 pounds weight. While this number of fish by no means represents the number caught, it very approximately shows the probable average weight.

In 1911, on July 18, a 12-pound chinook, on the 24th a 15-pound one, on the 28th another of 14 pounds, and on the 30th a 14¾-pound fish were caught at Split Rock. The latter measured 31½ inches in length, a female with eggs about the size of BB shot.

On August 3, one of 13 1/16 pounds was taken at The Hedgehog grounds.

On October 18 the Nashua fisheries station party took in a gill net set in about 3 feet of water a chinook which weighed 7 pounds when weighed two or three weeks after it was caught. It was found dead in the net. It was an immature female that would probably have spawned in 1912. The scales indicate about 3 years of age.

On the 19th one was taken in the same place, the length of which was 33 inches, depth 8¼ inches, girth immediately in front of the dorsal 20 inches. It weighed 16 pounds after about one month in retaining car, and had probably weighed 2 or 3 pounds more when caught. It was a male with well-advanced but still firm spermaries, which would have ripened that fall, but which were perhaps retarded by confinement in the fish car. The scales indicated about 4 years of age.

On October 31 the same party took a small immature male, 14½ inches long, off Hays Point, on "The Reef." On November 11 a small one 15¾ inches long was caught in the nets set for white trout on "The Reef," apparently an immature female.

The results of the introduction of chinooks into Sunapee Lake show that the conditions are to some degree favorable to their existence. It may be said, however, that the fact that a few hundred have been caught in the last three years, and some of them of fairly large size, does not prove that the stocking of the lake with this fish has been a complete success. In such an application of the term, "complete success" should signify that the lake has been permanently stocked; in other words, that it has become self-sustaining.

For the stock to be self-sustaining the conditions for growth and reproduction must be favorable. The results thus far indicate only that the conditions of growth from fry or fingerlings to well-conditioned adult fish are very favorable, and one of these conditions is the abundance of suitable food. But, to know that other conditions are favorable it must be shown that the fish can mature and breed here. In other words, having reached maturity, the stock must have favorable natural conditions for spawning, or else it must be possible to take sufficient numbers in breeding condition to produce an annual supply of young to replace the fish that have succumbed to the mortal breeding function.

Observations made upon a few fish taken in Sunapee Lake and elsewhere show that some permanent fresh-water residents of this species do reach maturity, but suggest that they do not all mature at the same time. It is not only possible, but quite probable, that there may be no definite breeding season. This may be accounted for by the fact that in its natural habitat there are two, or even three, more or less distinct runs, according to locality, so that the spawning covers nearly all summer and fall; and to be considered with this is the change to environment lacking the normal stimuli. In other words, any approach to innate regularity in this respect may be disturbed by permanent residence in fresh water. The habits of this salmon in Pacific coast waters indicate almost, if not quite, conclusively that on the spawning beds must be quick-flowing water of certain degrees of temperature, such as are found in the highland sources and tributaries of the rivers ascended.

Tributary streams with sufficient volume of water to allow the ascent of salmon to suitable spawning beds are wanting at Sunapee Lake. While in the absence of such streams salmon reaching spawning condition might deposit their eggs on shoals along shore or in the lake, the chances of more than an inconsiderable number, if any, hatching and reaching adult size are very slight.

It therefore devolves upon the fish culturist to assist the fish in making the stock self-sustaining. In order that this may be done there must be, as previously mentioned, fish enough secured in the fall to supply the requisite number of fertilized eggs to produce an adequate return to the lake. The question then arises, What constitutes the requisite number and adequate return?

There is no way of even approximately ascertaining how large a plant of young is necessary to produce what might be considered good average fishing in the lake. The results of the plant of one year may be very different from those of another, and what constitutes good fishing for a few anglers might afford a very poor general average for the many in a season. The fishing season extends variably from about April 15 to September 15, or approximately five months. More salmon are caught during the first half of the season, however, than the latter half, and it seems fair to estimate 100 days as the average salmon-fishing season. The number of chinooks planted in 1904 may be regarded as a negligible quantity in the catch of fish in 1909 and 1910, and assuming that none was planted between 1904 and 1908 (there are no records of such plants), the plants contributing to the catch of 1909 and 1910 would be those of 1908 and 1909. In round numbers there were 78,000 fingerlings planted in those two years, and the estimated catches of 1909–10 amounted to between 500 and 650 fish.

It is not known to the writer how many anglers fish at Sunapee, but Mr. Graham states (op. cit.) that 10 anglers were fishing there in 1910 to 1 twenty years ago. In Forest and Stream of October 23, 1890, it is stated that "as many as 25 boats have been anchored in one string at Sunapee Lake." Allowing only one angler to a boat, there would be 25 fishermen on this one ground alone. A very low, or at least conservative, estimate, it would seem, would be 200 anglers on an average at Sunapee Lake each season at the present time. Setting the catch for 1909 and 1910 at 600 undoubted chinooks, this allows only 3 fish to each angler in two years' fishing, and unless a sufficient number of other species are caught to satisfy the anglers this must be considered a very poor return for the money invested. Again, 600 fish is less than four-fifths of 1 per cent of the number of young chinooks planted. But, of course, there is no way of ascertaining how many of those planted survived or how many are still in the lake. It is therefore possible that nearly all the survivors were caught, or that only a small per cent of them were taken.

The unsuccessful efforts in the fall of 1911 to catch chinooks in breeding condition indicate either that the fish were very scarce or else that they had not reached maturity. If the latter is the case the fall of 1912 ought to reveal their presence, being about the fifth year from the time of hatching. If few or none can be secured in 1912, it will indicate that probably the 1908 plant has practically ceased to exist. Breeding fish of the 1910 plant, if the fifth year is correctly set as the breeding time, will manifest itself one way or the other in 1913, and so on. The angling record of 1912 will also contribute to the data for predictions. As it is, the fact seems obvious that the number of chinooks planted has not been sufficient to afford what may be called even good fishing, and unless the stock of the lake will reproduce to that extent the introduction of this fish may be considered a failure, for enough have been planted to demonstrate whether or not the lake can be made self-sustaining, so far as this fish is concerned.

There are those who have thought that the chinook successfully acclimated in fresh water as a permanent resident might reverse the laws of nature and continue to live after spawning. If there were not sufficient other evidence to the contrary, such hopes would be blasted by the report of the experiences with this fish in the Trocadero Aquarium, Paris, France, by Eugene Juillerat. After discussing the merits of the fish, he writes:

> By all of these qualities the *Salmo quinnat* recommends itself especially to the attention of fish culturists, and its culture would have been undertaken on a large scale if it were not for a serious drawback. After spawning in closed waters it always dies. For 20 years they have been cultivated at the Trocadero Aquarium, and never have I seen this fish live more than some months after the act of reproduction. So

certainly is this so that the symptoms which mark the approach of their spawning are also those of their death.

Such being the case, enough young must be planted every year to supply the demand of a constantly increasing number of anglers, as well as a sufficient number to insure breeders to furnish the supply.

The usual breeding age of chinooks on the west coast of the United States and at the Trocadero Aquarium is quite positively stated to be 4 years, although some, especially males, mature earlier than this and some are retarded somewhat longer. In Alaska it has been found that the usual breeding season occurs about the fifth year. It has in this report been previously suggested that if the Sunapee chinook has a regular breeding season it may occur in its fifth year. Therefore, if this is correct, a practically complete disappearance of each year's plant may be reckoned on by the end of the fifth year.

The more fish planted and surviving, the more will the anglers catch (unless there are enforced restrictions of the catches), and the number to be planted to produce the additional supply of breeders on that account must be increased and so on in an interminable progression. It is, therefore, as before remarked, obviously impossible to estimate even approximately how many need be planted to afford good average fishing and to insure breeders enough to maintain it. Even if the exact percentage of survivors of each plant could be known and the catch of each season could be regulated, it would be impossible to know that the required number of breeders could be secured even if present in the lake.

The foregoing facts indicate, to the writer's mind at least, that a permanent self-sustaining stock of chinook salmon in Sunapee Lake is unattainable.

The other game fish at Sunapee Lake at present offering any attractions to anglers are landlocked salmon, "native trout," white trout, and black bass—principally the white trout and black bass. The landlocked salmon still exists, but in very diminished numbers. The "native trout" is very scarce in the lake. The white trout and black bass are fairly common, but do not seem to attain as large a size as in former years. Of the salmon family, then, the principal fishing is for chinook salmon and white trout.

The white trout began to decrease in numbers as the landlocked salmon increased. But for some reason the landlocked salmon then began and continued to fall off in numbers, perhaps for reasons suggested in the discussion of that species. The white trout increased gradually in numbers again under improved fish-cultural methods and larger plants. Authentic instances have been cited where chinooks have been found with one or more white trout in their stomachs. An occasional white trout in the salmon's stomach does not prove that it is particularly dangerous to the white trout, but as the chinook is, like the landlocked salmon, notedly pisciverous, it is not unlikely that the chinook does devour many white trout; especially, as has been pointed out in another place, the disappearance of trout in some waters and the disappearance of the bluebacks from Rangeley Lakes can be laid at the door of the landlocked salmon.

In Sunapee Lake the principal food doubtless is the smelt, which probably even in deep water swims in schools, and on that account is particularly liable to the attacks of chinooks, which, from a foregoing discussion of the chinook's feeding habits in its original waters, subsists mainly upon such fishes as swim in schools. It is not impossible, however, that the white trout may also occur in schools. If so, the trout is surely in danger, and even if the trout are only mingling with and feeding upon smelts they are liable to be snapped up by chinooks also feeding upon smelts. While the unknown factors entering into the calculation are so many as to make the figures of little or no value, the following computation will serve to indicate the tremendous possibilities:

Let each salmon eat one trout each day for 180 days or practically half a year. Then each salmon devours in that length of time 180 trout; 500 salmon would destroy 90,000 trout in that length of time. At this rate it would take only slightly over 2½ years to destroy a number equal to the largest plant of white trout made by the Bureau of Fisheries, less than 6 months to destroy a number equal to the plant of 1911, and only a little less than 23 years to eat up a number equal to all that have been planted by the State and Federal fish commissions in 15 years—something over 2,000,000. (See table.)

The white trout among the Salmonidæ is of unsurpassed beauty, unexcelled delectability for the table, and a most satisfactory game fish, occurring in but a very few known localities in the United States, and diminishing or already extinct in some of them. Here the stock could be maintained, as shown, by the successful fish-cultural operations and a brief respite from salmon. It would be a reproach to exterminate the fish. Will it pay to take the chances and continue to introduce those voracious species, especially the chinook, which is otherwise such an uncertain quantity?

The discussion of the chinook in the foregoing pages relates to conditions up to and including 1911. The large catches of this species in 1912 and 1913 in no way detract from the arguments made in that discussion. The majority of those caught were evidently of comparatively recent plants. In a letter to the present writer, Mr. George H. Graham stated that he had kept a fairly good record of the fish taken in 1912 and considered 1,800 a conservative estimate, and that they ran from 2½ to 6 pounds each. A few of 10 and 11 pounds were also reported. In the same letter Mr. Graham wrote that white trout were caught "about as usual," plenty of them, but not many large ones.

About the middle of May of this year (1913), Mr. W. O. Robinson, of Washington, D. C., who had just returned from Sunapee Lake, informed the writer that many chinooks up to 4 or 5 pounds in weight were being caught this spring, but scarcely any white trout were taken. (For further discussion of 1912 and 1913 see page 91, footnote.)

Observations upon young chinooks.—It seems to be a general impression among those who handle and plant young chinooks at Sunapee Lake that if planted in the brooks they soon go down to the lake, at least after the first heavy rain following the planting. Their presence in the brooks during and subsequent to the runs of smelts gave rise to the idea that they returned to the brooks with the smelts after having been in the lake over winter. Particular attention was given to this point during April of 1910. During this time observations were made several times nearly every day and every night at the mouth of Pike Brook and no young salmon were ever observed entering the brook by themselves or with the smelts, but throughout April some young about 3 to 3½ inches long were present in the brook above the dead water. It is not impossible, however, that they entered the brook from the lake prior to the run of smelts, but, if so, it must have been prior to the breaking up of the ice in the lake.

It was observed that young chinooks planted in the brook at a considerable distance from the lake soon distributed themselves up and down the brook indiscriminately. Some planted not far above the dead water distributed themselves in both directions, but the majority went upstream, those going downstream at first stopping short of the dead water, probably affected by the rise in the temperature of that portion of the brook. An interesting and perhaps significant fact is that the last-mentioned plant was placed in a pool some 3 feet deep which evidently was directly fed by a spring, which reduced the temperature of the water to 50° F., that of the rest of the brook in its neighborhood being about 57° or 58° F. No salmon remained in this pool. Several plants were made here, but the fish invariably left it so quickly that in a few hours none could be found in it. It is also shown that while some of the young salmon made their way up the brook for a considerable distance beyond the place where they were planted, none entered the open water of the meadow, where the temperature rose to 59° F.

At no time during spring and summer were any young chinooks observed entering the lake. In order to ascertain if there were any such movement, a small fyke net set in Pike Brook a short distance above the dead water up to August 16, 1911, contained at any one time only three or four young chinooks and the net almost completely occluded the brook. On the 16th the fyke net was removed to the outlet of the dead water through the beach. About noon of the 18th there was a heavy downpour of rain. The following morning the net contained 18 young chinooks, which gives some support to the idea that these young fish enter the lake after a heavy rain.

Subsequently larger numbers were found in the net, but the number at any time represented but a small portion of those that had been planted, even in the last deposit.

During the spring and summer the stomachs of young chinooks of the brooks were examined in order to ascertain the character and quantity of food. One taken April 17, 1910, contained caddis larvæ and a lot of smelt eggs. During August, 1911, young taken in the fyke net contained small insects, mostly *Diptera*.

Having examined the shore water of the lake and the water of various parts of the brooks in regard to food supply for young salmon, it was decided that the brooks, especially Pike Brook, were preferable to the lake for the purpose of planting young salmon, not only on account of the greater food supply of the brooks but their comparative freedom from enemies. That there were some enemies, even in the brooks, was evident. At one time two kingfishers were observed industriously catching small fish, presumably young salmon, just above the dead water. On two occasions some trout were opened and found to have been feeding upon recently planted chinooks. One 10-inch trout contained six salmon in various stages of digestion.

SILVER SALMON (*Oncorhynchus kisutch*).

The silver salmon, known in Alaska as "coho," has its geographical range from San Francisco probably to the Yukon and on the Asiatic coast south to Japan. It reaches a weight of 15 pounds and averages perhaps 8 or 9 pounds. It is especially abundant in Puget Sound, where it is frequently caught by trolling, and it is stated that these fish take herring bait the year round in Puget Sound and bays of Alaska, and on the offshore banks.

The silver salmon ascends streams, but not so far as some chinooks, and the breeding runs are later in the season. Like the chinook, all die after the breeding function is performed.

The adult fish subsists largely upon other fishes, particularly those that swim in schools, such as the herring, smelts, sand launces, etc. In fresh water the young up to the fingerling stage feed mainly upon insects and the aquatic larvæ of insects, and fingerlings have been found containing small fishes and fish eggs. Yearlings in salt water also subsist largely upon smaller fishes.

It is a good food fish, for packing ranking third of the five species of the genus *Oncorhynchus*. It is also a gamy fighter, but does not excel the eastern landlocked salmon. As it is a voracious fish eater, nothing can be gained by its introduction into Sunapee Lake.

The reports of the Bureau of Fisheries show that in 1909, 15,000 fingerlings (?) were planted in Sunapee Lake. None has as yet been reported, although it is possible that some of the supposed small chinooks may have been silver salmon.

The fish may be readily distinguished from the landlocked salmon, or any other eastern salmonid, by the larger number of anal rays, but this character may not infallibly distinguish it from the chinook. The silver salmon has 13–14, the chinook 15–17 anal rays. Those accustomed to seeing and handling the fish can readily distinguish it by its general appearance and coloration, but this would be rather difficult for one more or less unfamiliar with either the chinook or silver salmon. The color is thus described by Jordan and Evermann in Fishes of North and Middle America:

> Bluish green; sides silvery, with dark punctulations; no spots except a few rather obscure on top of head, back, dorsal fin, adipose fin, and the rudimentary upper rays of the caudal; rest of caudal fin unspotted; pectorals dusky tinged; anal with dusky edging; sides of head without the dark coloration seen in the quinnat [chinook]; males mostly red in fall, and with the usual changes of form.

One who has the patience to count the scales in the longitudinal series immediately above the lateral line will find from 125 to 135 in the silver salmon and from 138 to 155 in the chinook. The most conspicuous internal difference is the number of pyloric cœca, which, in the silver salmon, is from 50 to 80 and in the chinook about 140 to 185.

Landlocked Salmon (*Salmo sebago*).

The attribute "landlocked" is a misnomer, first applied to this fish owing to the early theory that the fish was derived from the anadromous sea salmon having been confined in the lakes by some upheaval shutting off return to the sea. The fact stated briefly seems to be that like many other fishes of the salt and brackish water ascending to fresh water to spawn, some remained in fresh water, thus establishing a fresh-water race or species, if this fish can be considered a distinct species. Without entering into a discussion of this question, it may be said that there seem to be sufficient constant differences to permit of its being so considered. The differences are no more pronounced than they are among other recognized species of salmonids, but they are as recognizable and, so far as has been determined, are real and constant.

Distribution.—The landlocked salmon, for which a better name would be fresh-water salmon, naturally occurred in only a few known localities. The New England fish originally was found in only four river basins, i. e., St. Croix, Union, Penobscot, and Presumpscot. In the St. Croix it occurred in some of the lakes of both branches, but the western branch at Grand Lake is the best-known water for it now. This is the source of the "Schoodic salmon" of fish culture.

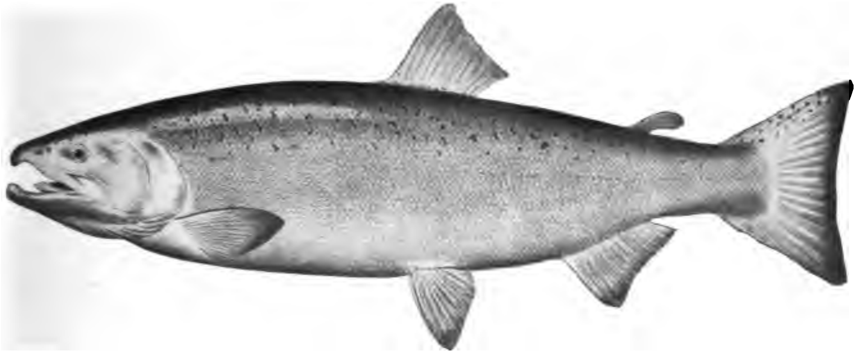


FIG. 1.—SILVER SALMON. BREEDING MALE.

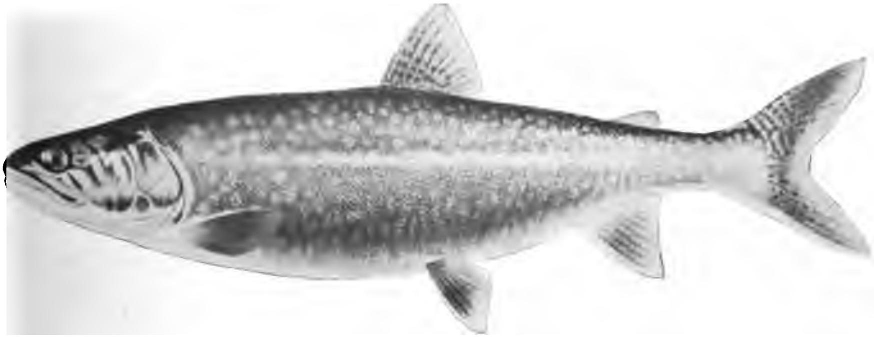


FIG. 2.—LAKE TROUT.

In the Union basin it was found only in Reeds Pond, now known as Green Lake. In the Penobscot, the only water in which it was formerly known is Sebec Lake; and in the Presumpscot, Sebago Lake was the only lake noted for the salmon. From this lake the fish gets its name and there it attains the largest size of any of the waters mentioned.

Culture.—Efforts were made by the New Hampshire Commission to secure eggs of the Sebago and Sebec salmon but without apparent success, so it seems that this fish in Sunapee is the result of plants from "Schoodic" stock. If this is true it shows that the little "Grand Lake salmon" under more favorable conditions attains a much larger size than in Grand Lake.

According to the reports of the State Fish and Game Commission, the first plant of this fish was made in 1867, when 45 or 50 were placed in the lake, and the report for 1877 states that "of the 45 put into Sunapee Lake, 43 are said to have been speared the next autumn on their spawning beds in one of the brooks flowing into the lake." This being so the fish first introduced must have been adults.

The first definite reference to the taking of landlocked salmon in Sunapee Lake is in the report for 1884, where it says: "In the summer of 1883 a large number were caught, weighing 5 to 7½ pounds, in Sunapee Lake." Again, in the report for 1886, it is said:

> In 1884 quite a number were caught from Sunapee Lake; in the fall of 1885 several were caught near the hatching house at New London, from which several thousand eggs were taken, being the first eggs ever taken from waters that have been artificially stocked with this fish in the United States. They have become quite plenty. Large numbers have been taken the present season weighing from 6 to 20 pounds.

The report for 1889 says:

> The work of securing eggs for the hatchery was commenced in September. A fine lot of landlocked salmon was taken the last week of that month. The weight of the spawners was from 4 to 12 pounds. Seventy-five thousand eggs were secured.

And again:

> Sunapee Lake has now become self-sustaining. Seventy-five thousand eggs were taken there last year, which is more than necessary to keep up the fishing to its present high standard, and no benefit has been received from the large plants made during the past three years.

The report of 1890 says:

> The landlocked salmon were found in greater numbers than ever before, and the requisite number for spawners were soon secured. After securing over 110,000 eggs the salmon were allowed to go up the brook and deposit their eggs naturally. This is the largest number of landlocked salmon eggs that has been taken at this station. The spawners were all secured at the mouth of the brook near the hatchway [sic]. The average weight was from 8 to 10 pounds.
>
> The lake is becoming noted far and near as a salmon lake, and the wonderfully rapid growth made by these fish proves conclusively that the water and food supply are well adapted to their wants.
>
> A large number of salmon weighing from 10 to 14¾ pounds have been taken with rod and line the past season.

A correspondent of a sportsman's paper in that year stated that fully 1,000 pounds of landlocked salmon, from 5 to 14¾ pounds, were caught in Sunapee Lake that season. The 14¾-pound fish was the largest then on record.

The report for 1891 states that owing to the unusually low water no salmon could find their way into the brook, and not as many females could be secured as were taken the year previous.

The report for 1892 shows that there was a large increase of salmon over the previous year, and that for 1893 says more of all kinds of parent fish were taken that year than in any previous year, including landlocked salmon. The report of 1894 says:

> What disciple of Izaak Walton while fishing in Sunapee Lake, previous to the organization of the New Hampshire Fish and Game Commission, ever felt the thrill that can only be imparted to the good right arm of the fisherman by striking the royal landlocked salmon, weighing from 10 to 15 pounds? Now that regal fish abounds in those waters to such an extent that hundreds are taken in a single season.

In another place the same report mentions that in 1893, 110,000, and in 1894, 140,000, landlocked salmon eggs were taken, and says:

> Owing to the extreme low water both at Sunapee and Pleasant Pond, our product of landlocked-salmon and brook-trout eggs is not more than one-half what it would have been under favorable conditions.

These are the last references to the abundance of salmon, but for some years longer nearly all of the fish planted were the products of eggs taken at Sunapee Lake, and the number of fish planted will indicate to some extent whether the salmon are holding their own, increasing, or decreasing in numbers.

The report for 1893, however, does not show that any salmon were planted that year. The report for 1894 makes no definite mention of salmon planted in Sunapee Lake, but states that 2,000 were sent to Sutton (probably for Pleasant Pond) and 105,000 to New London (probably for Pike Brook). Unless 5,000 fry allotted to Sutton in 1895 were placed in the headwaters of Pike Brook, no plants were made this year in Sunapee Lake waters. The records begin again in 1896, with 30,000 fry. There seems to have been no plant in 1897, but in 1898 50,000 are recorded for Sunapee Lake. None is mentioned for 1899, although the salmon planted in other lakes may have been from eggs taken at Sunapee. The report for 1900 shows 35,000; those for 1901 to date give no plants for Sunapee Lake, except that 1904 gives 23,000, but it is not certain that these eggs were taken there. All subsequent plants were made by the United States Bureau of Fisheries, perhaps some from eggs taken elsewhere.

In 1904 the Nashua fisheries station party took 36 salmon, 27 of which were males and 9 females, yielding 25,000 eggs; in 1905, 22 salmon were caught, 19 males and 3 females, yielding 1,000 eggs; 1906, 10 salmon, 8 males and 2 females, yielding 6,000 eggs; in

1907 no salmon were taken; in 1908, 4 salmon were taken, 3 of which were females, but no eggs were obtained; in 1909, 1 female only was caught. An unsuccessful attempt was made to fertilize the eggs with chinook milt.

In 1910 the Nashua fisheries station party began setting gill nets September 15, attempting to get chinooks. Up to October 14, only a few small trout and two landlocked salmon of about 5 or 6 pounds each had been taken.

October 17 three gill nets, each 100 feet long, set in a string offshore in water from 1½ to 4 or 5 feet deep, near the mouth of Pike Brook, just about dusk took two salmon, one a female estimated to weigh 8 pounds, the other a male of about 6 pounds. The male has a strongly hooked lower jaw, and was more slender than the female. The female was plump and pretty, full of roe, but not ripe, although well advanced. The abdomen was plump and hard, contracting about the vent. The male had a short gash in its side which was somewhat fungus-grown.

In 1911, on September 24, Mr. DeRocher caught in a gill net off the "Banks," in about 30 feet of water, a female landlocked salmon; on November 6, in nets off mouth of Pike Brook, one ripe female of strong 5 pounds was taken; and on November 10, at the "Reef," the fisheries party took in a gill net one landlocked salmon 17½ inches long, apparently a male.

The following is a record of the plants of young landlocked salmon in Sunapee Lake, as shown by the New Hampshire and United States Fish Commission reports:

1867	50
1877	700
1878	6,000
1879	10,000
1881	4,000
1882 (by United States)	15,000
1882 (by State ?)	5,000
1884	15,000
1885	10,000
1886	25,000
1887	40,000
1888	45,000
1889	75,000
1890	95,000
1891	65,000
1892	34,000
1894	105,000
1896	30,000
1898	50,000
1900	35,000
1902 (by United States)	59
1903	20,000
1904	3,000
1904 (by United States)	8,250
1905 (by United States)	1,120
1906 (by United States)	13,640
1907	12,000
1907 (by United States)	12,905
1909	4,000
Total	739,724

The catch of "a large number weighing from 5 to 7½ pounds" in 1883 must have been from the plants of the years 1877 to 1882, inclusive, the extreme period of growth to these weights being about five years. In about 12 years from the first plant in the lake Sunapee salmon stock was considered self-sustaining. The fish planted by the State, presumably from Sunapee salmon eggs, in 1889 was 75,000; in 1890 an increase of 20,000 appears; then a gradual falling off, in 1891 reduced to 65,000; 1900, 35,000; 1902, none at all; but in 1903, 20,000, and in 1904, 3,000, probably from eggs taken elsewhere.

The catches of the United States fisheries station party show a rapid decline in the number of landlocked salmon obtainable in Sunapee Lake for propagation purposes. This is doubtless due to two things: First and directly, to the inability of the fish to find suitable spawning waters. At one time it seems to have been possible for them as well as the trout to enter Pike Brook, but later, owing to low water in the lake and in the brook, too, without doubt, the salmon were unable to enter the brook. The secondary cause, depending upon the first, is the fewer young planted each succeeding year. Yet there are some landlocked salmon in the lake, though they are fast disappearing, as they have no natural breeding grounds and are gradually caught or die naturally.

Habits.—The salmon requires for breeding a gravelly bottom with cool running water, and while it is known sometimes to deposit its spawn along shores of the lake, it is doubtful if more than a few eggs, if any, hatch. The salmon ascends streams to the spawning beds, where it forms its "nest" some time before it is ready to deposit its spawn. In some waters it enters the streams early in September and the State Fish Commission reports indicate that it was found entering the brook or attempting to do so in the latter part of September in Sunapee Lake. The spawning takes place in the latter part of October to some extent, but mainly in November. The eggs hatch in the spring and the young remain in the streams until they attain a length of 4 or 5 and even in a great many instances 8 or 10 inches, thus not subjecting themselves to the dangers that beset very small fish in the lake. If the spawning beds where the fish are hatched are in a large stream, when able to swim the young make their way upstream or into smaller running tributary brooks, if there are any, in this respect just like the species progenitor, the "sea salmon." A few young "landlocks" were observed in 1910 and 1911 in Pike Brook. On April 28, 1910, one fingerling was seen in Pike Brook and on August 12 three about 2 inches long were caught in Blodgett Big Brook. On July 29, 1911, several about 8 inches long were caught by means of hook and line in Pike Brook, and on November 3 one was taken with the outrun of trout from Pike Brook.

The adult salmon is primarily a fish eater, but it also subsists largely upon insects that fall upon the water and aquatic larvæ of insects. In its natural habitat the smelt is its principal food and no landlocked salmon ever occurred naturally where there were no smelts. In fact, the spring runs of the sea salmon seem to be in pursuit of food to some extent at least, and on the Maine coast this is

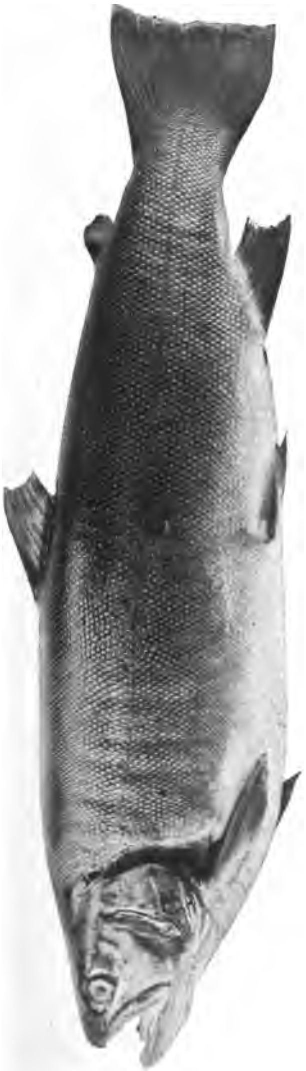


FIG. 1.—FOURTEEN-POUND LOCK LEVEN TROUT, OR BROWN TROUT.

Identity not certain because of confused records of plants.

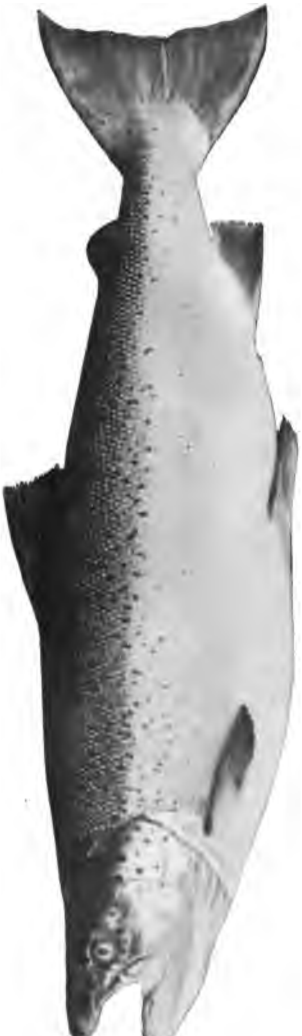


FIG. 2.—SIXTEEN-POUND LANDLOCKED SALMON.

largely the smelt, and the smelt may be largely the "obstruction" that landlocked the salmon. In other words, salmon having entered a lake and ascended its inlet or inlets to spawn, as they began to return, finding abundant natural food in the smelt, they were, or some individuals were, content to stay in the lake. Or it may be that the young, lingering as they do in their native streams sometimes for two and three years and there attaining a weight of at least half a pound or more, on entering the lake from the inlet or outlet found congenial surroundings in the way of temperature and food and remained. Whatever the facts of the landlocking process, the one fact remains that it is easy to stock a lake having the requisite conditions with landlocked salmon, thus indicating that but a few, if any, of the salmon attempt to go to sea. The landlocked salmon does, however, in spawning season, descend into outlets, where it breeds. Also salmon have been known to follow a drive of logs, presumably for the sake of grubs and insects dropping from the logs. But young landlocked salmon have never been detected going to sea in the manner of the young of "sea salmon."

The young salmon is largely an insect feeder until it comes in contact with the smelt. It takes whatever insects it finds fallen upon the water and seeks the larval aquatic forms occurring on stones and submerged logs.

Angling.—The usual method of fishing for salmon in the lakes is by trolling with natural or artificial bait, but the fish will take the fly, especially in the early evening, when insects are at the surface of the water. As has been suggested elsewhere, the reason why salmon are not rising to an artificial fly may be because there are no such flies for them to rise to, or there may be no salmon to rise to them, or, it may be added, the fishing may be at an improper season or time of day. In 1890 a prominent summer resident at Sunapee Lake commenting in a sportsman's journal upon the fishing of that season, among other things, said: "Fly fishing for bass never was finer. While casting a small brown hackle the other evening we raised a 10-pound salmon, but he missed the fly." Mr. Ralph Davis states that he formerly caught landlocked salmon on flies at the mouth of Georges Mill Brook. Only one recent definite record of landlocked salmon caught by anglers was available, perhaps, as has been previously suggested, because they were not always distinguished from chinooks. This record referred to a 12-pound fish taken at Split Rock on July 29, 1911.

This fish is unsurpassed as a game fish and is an excellent food fish. Its size and activity make it very attractive to the angler. But the foregoing discussion of its habits indicates that it is an undesirable acquisition where it is desired to maintain the stock of trout. In other places in this paper allusion has been made to the effect of its introduction into trout waters. The greatest damage has been done in those waters where it was introduced without a preceding or accompanying introduction of smelts. On account of the introduction of smelts, the damage in Sunapee was lessened or shortened. Nevertheless, it appears to have been great, especially so far as the "native trout" was concerned. The writer may be biased, but he deplores the fact that salmon were ever put into Sunapee Lake.

RAINBOW TROUT (*Salmo irideus*).

The rainbow trout occurs naturally in the streams of the west slope of the Sierra Nevada and the Coast Range Mountains, and is found as far north as southeastern Alaska. There are several local varieties or variations which have been given specific names and which in Jordan and Evermann's "Fishes of North and Middle America" are recognized as subspecies.

The form that has been propagated and distributed by fish culture is the McCloud River (California) rainbow trout, technically known as *Salmo irideus shasta.* Its geographical range is stated by Jordan and Evermann as streams of Sierra Nevada from Mount Shasta southward. It is said to reach a weight of 10 pounds. It subsists largely upon insects, worms, insect-larvæ, and Crustacea, and although it is not naturally a fish eater, when fish are available it does not always disdain them.

In its native waters the rainbow trout spawns during the months of February, March, and April, but it has been found to vary from this in the different places where it has been introduced. At Wytheville hatchery the spawning season extends through November, December, and January, and, to some extent, into February. December and January are the best months. In Colorado the period is from early May until July. It is stated that the maximum number of eggs produced in a single season by a 3-year-old fish weighing ½ to 1½ pounds is from 500 to 800; from one 6 years old, weighing 2 to 4 pounds, it is 2,500 to 3,000.

This fish has been successfully transplanted into streams in the Eastern States where the conditions seem to be favorable. Rainbow trout will live in warmer water than the brook trout. Probably warmer waters are required and the coldness of New England waters may be the cause of the poor results in stocking them with this fish.

Rainbow trout have been planted in Sunapee Lake as such and under the name of "California trout" as follows: 1888, 10,000; 1889, 25,000; 1890, 10,000; 1891, 10,000; 1903, 2,994; total, 57,994.

No one has as yet reported a rainbow trout from Sunapee Lake. However, the comparatively small number planted in the presence of other fish-eating fish may be the reason for the apparent failure to stock the lake. It is a profusely black-spotted fish, and could be confused with no other salmonoid in the lake, unless possibly the chinook and landlocked salmon. From the former it may be distinguished by the fewer anal rays and from the latter by the finer or larger number of scales in the lateral longitudinal series, the landlocked salmon having not over 120, usually 115, all told, and the rainbow having 145, more or less. It is a delightfully gamy fish as a rule, and readily takes the artificial fly. It usually makes a long hard fight.

Considering the comparative harmlessness of the rainbow trout compared with the chinook and landlocked salmon, it seems a pity that the waters of Sunapee are not more favorable to it and have not received more plants, if it seems necessary to stock it with non-indigenous fishes.

Brown Trout (*Salmo fario*).

The fish better known in this country as brown trout was first introduced under the name of Von Behr trout, after the man through whose instrumentality the eggs were obtained from Germany. It was later called German brown trout and finally just brown trout. In Great Britain it is known as brook trout, burn trout, and brown trout, also having many other names for local variations. In Germany it is the Bach-forelle (brook trout), but it is not exclusively a brook trout any more than the eastern brook trout of the United States (*Salvelinus fontinalis*) is such. It also inhabits lakes, in some of which it reaches a large size, even 50 pounds, if the British *Salmo ferox* is the same species. Day, in his "British and Irish Salmonidæ," 1887, gives the habitat of this trout as the colder and temperate portions of the Northern Hemisphere, descending in Asia as far south as the Hindu Kush, but not normally present in any portion of Hindustan.

It has been introduced into many United States waters, in some of which it has thrived. It is a good game fish, but Henshall says it is not as gamy in this country as the eastern trout (*S. fontinalis*). It will endure warmer water than *S. fontinalis* and may be suited to depleted trout streams which, owing to change of conditions, are unsuited to the brook trout.

Day says:

> The food which trout consume is of various descriptions. One of about 1½ pounds weight, taken in June, 1882, in the Tweed, was found to contain 11 small trout and 1 minnow. They do not object to little fish, as the minnow, loach, sticklebacks, etc, water rats, young birds, frogs, snails, slugs, worms, leeches, maggots, flies, beetles, moths, water spiders, and even a lizard (Field, October, 1885). They will swallow one of their own kind two-thirds as large as themselves. In Mr. Buckland's museum was an example, the stomach of which was distended by 2,470 eggs of apparently the salmon.

Regarding their breeding habits, Day continues:

> Trout commence breeding in their second year or prior to their attaining 24 months of age, and often later in the season than their parents. The males are more forward than the females, but at this early period of their lives the probabilities of the ova being healthy and fertile are less than in somewhat older examples. At first the number of males appears to be in excess of the females, but the mortality among them is greater than those of the other sex, until at 3 or 4 years of age the proportion may be expected to be about the same, and subsequently the females predominate. The number of eggs produced by each female trout has been roughly estimated at 800 for every pound's weight of fish, which computation has been observed at the Howietoun breeding ponds to be fairly accurate. * * *
>
> The period at which these fish breed varies in different rivers and districts, extending from October until February, and even, although rarely, to March. * * *
>
> Although trout generally migrate into the smaller contiguous brooks to breed, large ones are more frequently found forming redds in the broader streams than are smaller fish. But it is by no means rare to find large examples having taken possession of pools in burns.
>
> A trout's redd or nest is a mound of gravel which would fill one or even two wheelbarrows, and when by probably causing a shallow may assist in aerating the water. The eggs themselves lie loose among the gravel at from 1 to 2 feet below the surface.

From the foregoing account of the brown trout, it would not seem to be a very desirable acquisition in waters where the indigenous fish fauna is wholly satisfactory.

There seem to be no records of this fish having been introduced as such into Sunapee waters, but as stated in the discussion of the Loch Leven trout it is possible that so-called Loch Levens were brown trout, and Day claimed that the Loch Leven is only a local variation of the brown trout. A 14-pound fish which was supposed to be and was recorded as a Loch Leven trout caught in 1910, but which seems to be a brown trout, affords the only possible record of this species from Sunapee Lake. This is referred to under the account of Loch Leven trout in the following pages.

LOCH LEVEN TROUT (*Salmo levenensis*).

This trout derives its name from the lake or loch in Scotland known as Loch Leven. It was formerly supposed to be peculiar to the loch, and the fish of the appearance, form, and coloration of the trout described and named *Salmo levenensis* undoubtedly was peculiar to the lake. It is stated, however, that fish reared from Loch Leven trout eggs in some waters can not be distinguished from the brown trout (*Salmo fario*).

Dr. Quackenbos states that he has fished in Loch Leven and that both kinds of trout were caught there and they are of widely different appearances.

Fish have been reared from eggs supposed to be those of Loch Leven trout sent from England to this country, but they could not be told from brown trout, which they probably were. Yet there have been some undoubted Loch Leven trout raised and distributed in this country. The two fish as they appear are as different in shape and color as the common eastern brook trout and the landlocked salmon. In fact the Loch Leven up to 2 or 3 pounds strikingly resembles the landlocked salmon in general appearance. It is more slender and silvery than the brown trout, having usually only black X-shaped spots but sometimes round brown spots, and the tail is more forked or emarginate than the brown trout.

The records given in The Fishing Gazette (London) of May 4, 1912, indicate the sizes of this trout as caught in Loch Leven to-day. From these records it was found that 329 trout in the aggregate weighed 240¾ pounds, which gives an average of about 11½ ounces. The largest mentioned was one of 1 pound 14½ ounces.

The Loch Leven trout is also more gamy than the brown trout. Day states that it will eat anything from bread to cockroaches. It is traditional that until in comparatively recent years the Loch Leven trout would not take a fly. Day ascribes this to the disappearance of its former food so that it resorted to insects.

Four plants of what were supposed to be Loch Leven trout have been made in Sunapee Lake. The first is referred to in the New Hampshire Fish Commission report for 1887 as follows:

> Through the kindness of Prof. J. D. Quackenbos, of Columbia College, New York, we have received a present of 30,000 trout eggs from Loch Leven, Sterling, Scotland. These eggs were purchased by Prof. Quackenbos, at an expense of about $5 per thousand, from the Howietoun fishery.

Again in the report for 1888 and 1889 it is stated that 30,000 young were planted in Sunapee Lake, presumably in 1888. The plants were as follows: 1888–89, 30,000; 1890, 10,000; 1891, 10,000; 1892, 25,000; total, 75,000.

Two or more fish have been caught by anglers and pronounced Loch Leven trout. The photograph of one of these, a 14-pound fish, seen by the writer, is believed by him to be of the brown trout, *S. fario*, which, if true, indicates that Day's contention that the Loch Leven trout is but a local variation of the brown trout (*S. fario*) is true, or that some of the supposed Loch Leven trout planted were brown trout, as no brown trout plants have been recorded for Sunapee Lake.

LAKE TROUT (*Cristivomer namaycush*).

This fish is the lunge or longe of northern New Hampshire and Vermont, the laker of Maine and New Hampshire, the togue of Maine, the Mackinaw trout of Michigan, and the masamacush or namaycush of eastern Canada and Labrador. The Indians of the interior of Labrador call it namaycush with the accent on the second syllable, according to Donald B. McMillan.

Its recorded geographical distribution is in deep lakes throughout the eastern Canadian Provinces, northern New England States, New York, Great Lakes, headwaters of the Columbia and Frazer Rivers, streams of Vancouver Island, northward into Alaska, Labrador, and the Arctic Circle. In some waters it reaches a weight of at least 100 pounds and varies much in size and color in different waters. It is a voracious fish, subsisting mainly upon other fishes, and is better entitled to the cognomen of "freshwater shark" than the pickerel or pike.

It spawns in the fall like other New England Salmonidæ, and usually upon shoals in the lakes.

In some sections it is highly esteemed as a food fish; in others it is regarded as inferior. As a game fish it is also variously regarded. It is usually caught by trolling or still-fishing, but has been taken on artificial flies. It often puts up a strong fight by powerful, short runs, dragging down, and sulking. It never leaps from the water, and its principal virtue as a game fish consists of its power and the size attained.

As previously stated, it is indigenous to New England waters, but it has also been introduced from the Great Lakes under the name Mackinaw trout. There are no records of its ever having been planted in Sunapee Lake. It occurs there, in limited numbers fortunately, probably gaining access by accidentally getting mixed with other salmonids from some station furnishing the young fish to be planted there.

The following are all of the known records of lake trout taken in Sunapee Lake.

1909.—Two, both males.

1910.—October 18, in nets in front of fishery cottage, Mr. De Rocher got a female 26 inches long. Eggs ran freely, yet judged not fully ripe. It is probable that lake trout do not deposit eggs all at once.

A young man from Sunapee Harbor said that two or three "lakers" had been caught with hook and line this season.

October 20, in the afternoon, near mouth of Blodgetts Brook, a fish with large head and emaciated body, about 16 or 18 inches long, was seen, which from the color of the sides and general appearance was thought to be a lake trout (male). It would not allow a close approach.

COMMON TROUT (*Salvelinus fontinalis*).

This fish is the "native trout" of Sunapee Lake, the name probably of comparatively recent adoption to distinguish it from introduced forms. It belongs to that group of boreal salmonids properly designated as charrs, is one of the charrs peculiar to North America and has a comparatively restricted range even there. Its stated geographical distribution is from Nova Scotia, New Brunswick, and the New England States to the Saskatchewan and northward to Labrador; also in the Northern States west to northern Minnesota and southward in the Alleghanies to the headwaters of the Savannah, Chattahoochee, Catawba, and French Broad Rivers.

The trout has numerous local names, as squaretail, red spot, brook trout, etc., which like that of Sunapee Lake, serve, locally, at least, to distinguish it from some other forms of Salmonidæ.

The distribution of *S. fontinalis* is governed mainly by the temperature of the water, and in its natural habitat it seems not to endure a temperature of over 60° or 65° F. In many of the long-settled portions of the country where the woods have been cut from the surrounding area and from the banks of the streams, the trout has practically disappeared. In the words of Dr. Henshall, which are a graphic expression of a well-known fact:

> The altered conditions of its aboriginal environment, owing to changes brought about by the progress of civilization, have resulted in its total extinction in some waters and sad diminution in others. In many instances the trout brooks of our childhood will know them no more. The lumberman has gotten in his work; the forests have disappeared, the tiny brooks have vanished. The lower waters still remain but are robbed of their pristine pureness by the contamination due to various manufacturing industries. In such streams the supply of trout is only maintained through efforts of the Federal and State fish commissions. It is hoped by this means the beautiful brook trout, the loveliest and liveliest of fish of all the finny world, may be preserved and spared to us for yet a little while. (James A. Henshall, in "Favorite Fish and Fishing," 1908.)

This article, as indeed most popular trout articles, pertains to the trout as "a brook trout." The trout, while naturally a permanent resident of many brooks and streams, is also a resident of ponds and lakes, in some of which it attains a large size, even more than 10 pounds in weight. The "progress of civilization" has also had its effect on the lacustrine trout. As the fish, whenever possible, ascends streams from ponds and lakes to spawn, the lumbering operations, by destroying the spawning places, have been fully as effective in the diminution of lake and pond trout as of the brook trout, especially in such ponds or lakes as have no suitable spawning grounds in them.

But lumbering operations are not alone to blame for the disappearance of trout or their decrease in numbers. As has been pointed out in another place in this paper, excessive and untimely fishing are most destructive, particularly the catching of fish on their spawning beds and through the ice in the winter. Dr. Henshall, in the foregoing passage, expressed the hope that through fish culture this fish might be spared "for yet a little while." It doubtless has in many streams and lakes, but fish culture is also responsible for its diminution in numbers, if not complete extinction, in some waters. This, too, has been referred to in another place, but it will bear repetition. The introduction of more powerful and more voracious fishes has resulted in the great diminution of the native trout and, together with or added to the ill effects of excessive and untimely fishing, has in some instances, at least, notwithstanding the efforts to maintain the stock by artificial propagation, almost completely exterminated the trout.

Sunapee Lake itself appears to be a specific illustration of the effects of this combination of causes. This lake, according to tradition, at one time abounded in trout, which was the only known or recognized salmonid of those waters. Trout were killed on their spawning beds, caught through the ice, and netted in the lake from time immemorial, and, as has already been shown, the decrease in numbers of the trout by these means was hastened by the "successful" stocking of the lake with nonindigenous piscivorous fishes, especially the landlocked salmon. To one who will investigate matters it will become evident that where this salmon is introduced and thrives, for some reason or another, the trout diminishes in numbers and in some instances completely disappears. It matters not whether it is because the salmon devour the trout or for some other reason, the fact remains that the two species do not thrive together. It is true that in some waters where salmon exist a good many trout are still caught, but this is due to vigorous stocking of the waters with trout. Unless there is an adequate annual plant, as before stated, the trout gradually "go to the wall."

From 1877 to 1909, inclusive, over 700,000 landlocked salmon, yearlings and fingerlings, were planted in Sunapee Lake waters, and the reports show that from 1880 to 1910 a million young trout were placed in the same waters, or, to be exact, 273,741 more trout than salmon in 30 years of trout plants against 32 years of salmon plants.

In the reports of the New Hampshire Fish Commissioners no reference is made to the propagation of the trout until the report of 1876, where it is recommended that efforts be made to restock depleted streams. In the report for 1880 it is stated that there were in the hatching house 150,000 brook trout eggs, 75,000 of which were sent to Massachusetts and the rest to different parts of the State to replenish exhausted brooks, and in the same report is mentioned the first plant in Sunapee Lake from eggs of the "Rangeley trout." While the commission continued to hatch and distribute trout each succeeding year, no mention is made of any more being planted in

Sunapee until 1882, when a small lot was placed in the brook or lake at Newbury. The next report is that covering 1883 and 1884, in which the first mention of the trout of Sunapee Lake is made as follows:

> The drought for the past two years has been very severe for the many trout streams of the State. Some of them have been nearly dry. * * *
>
> Upon examination of the waters of Sunapee Lake, it was thought that a large number of brook trout spawn could be taken from the brook which enters the lake at Cass Landing in New London, where for many years they have ascended in large numbers during the spawning season. Hundreds have been taken with nets and clubs. So many had been destroyed that the commission was requested by citizens residing near the lake to protect it in order to increase trout fishing in those waters.
>
> Dr. J. D. Quackenbush [sic], the owner of the land through which this brook runs, desiring its protection, has leased the brook and adjoining land to the State for a term of years at the nominal rent of $1 a year. By permission of the governor and council, a small hatching house has been erected on this brook but a short distance from the lake of sufficient capacity to hatch half a million of spawn annually. The cost of the house is about $270.
>
> On account of the extremely low water caused by the large amount of water taken through Sugar River the past summer and fall for manufacturing purposes, drawing the water several feet below the usual low-water mark (in September it was lower than ever known before), the trout could not get into the brook, much to the disappointment of the commission, who had made arrangements to take a large number of spawn. Several large trout were taken in the lake near the inlet in shoal water. They yielded 15,000 eggs, which were successfully hatched and placed in the lake. * * *

Again, in the report for 1885 the following appears:

> In the house at Sunapee Lake are 65,000 brook-trout eggs. Many more would have been obtained there had it not been for the loss of many fish killed by thieves and poachers. Fortunately three of them were caught one night in the very act, and were fined $100 and costs each. It seems almost incredible that intelligent men, knowing the object of the work that was being done, would have placed themselves in so humiliating a position merely for the sake of a few pounds of fish unfit for food at that season. For years it has been the practice of these men, and their fathers before them, not only to kill every trout that came into the brooks in the fall, but to line the shores of the lake with gill nets, thereby destroying large numbers of trout as they came into the shoal water for the purpose of spawning; and they wonder why the fish have decreased. I only wonder that there is a trout left in the lake.
>
> This body of water, with proper care, can be made one of the finest trout lakes in New England. The trout are very large, 5 or 6 pound fish not being rare, and some have been taken weighing 9 pounds, and the large ones all get away, at least so say the fishermen, and while it is an easy matter to add to our food fishes by the introduction of new varieties and increase our native fish by artificial propagation, when we come to our wild game it is another question.

In the report for 1886 it is stated that at Sunapee Lake the commission succeeded in securing enough adult trout to yield 100,000 eggs, the trout being returned to the lake after the spawning season.

Again in the report for 1887 reference is made to the former poaching and the difficulty encountered with poachers in the operation of the hatchery, which was finished late in the fall of 1884. The following extract regarding the trout is of interest in this connection, indicating that but a few trout were supposed to be left in the lake:

> In 1884 many complaints were made to your commissioners regarding the illegal destruction of the trout in this lake during the breeding season.
>
> During the months of October and November it was said that the trout came into the brooks in large numbers, where they were killed with nets, spears, guns, and clubs. An investigation was made, and the commissioners were convinced that the complaints were well founded. It was proved beyond a doubt that it had been the custom to kill every trout that could be found either upon the spawning beds or attempting to reach them. It was evident that something must be done in order to save the few brook trout remaining in the lake. * * *
>
> Three of these poachers were caught in the act. * * * Since that time no attempt has been made to interfere with the work being done, and so marked has been the increase that one night last season 40 trout were taken weighing from 1 to 6 pounds each, and eggs enough to fill the house to its utmost capacity were easily obtained, and the number taken might have been doubled had there been room for them.
>
> Twenty thousand landlocked salmon eggs were taken and more could have been secured if there had been room for them in the house.

The report for 1888 states that the water was unusually high and most of the trout were taken in pound nets set at the mouths of the brooks. It is stated that eggs were taken from trout of from 1 to 7 pounds.

The report for 1891 says the number of brook trout taken was much larger than the previous year.

The following is quoted from the report for 1892:

> The first brook trout [at Sunapee] were taken September 13. The large increase in the number of these trout taken this year shows the effect of the heavy plants made the last four years, the number being double that taken last year.

The report of the Sunapee Station for 1892 says that the first trout were taken September 14 and that there was a large increase of salmon, but that, owing to stormy weather, not as many brook trout were secured as last year.

The biennial report for 1893 and 1894 indicates that 250,000 "brook trout" eggs were taken at Sunapee Lake in 1893 and 45,000 in 1894. Regarding the conditions in 1894 the report says:

> Owing to the extreme low water, both at Sunapee Lake and Pleasant Pond, our product of landlocked salmon and brook trout eggs is not more than half what it would have been under favorable conditions.

And in another place:

> Previous to the existence of the commission there were almost no fish, of the better varieties, in that beautiful lake [Sunapee]. To-day as a direct result of the labors of the commission, it abounds in beautiful brook trout, many specimens of which are taken each season, weighing from 3 to 6 pounds each, and this magnificent fish abounds in those waters to such an extent that no sportsman possessing a fair degree of skill and a reasonable amount of patience, can cast his line therein without a reasonable reward for his labors.

The following is a chronological list of the records of plants of the common trout in Sunapee Lake and tributaries as shown by the State and United States Fish Commission reports:

PLANTS OF COMMON TROUT IN SUNAPEE LAKE.

Date.	Number.	Where planted.	Date.	Number.	Where planted.
1880	[a]2,500		1899	40,000	Tributaries of Sunapee Lake.
1882	5,000	Newbury.			
1886	55,000	Sunapee Lake.	1900	35,000	Sunapee Lake.
1887	100,000	Do.	1901	4,665	Do.
1888	[b]150,000	Do.	1902	3,000	Do.
1889	80,000	Do.	1905	2,000	Do.
1890	50,000	Do.	1906	1,500	Do.
1891	68,000	Do.	1907	11,000	Do.
1892	125,000	Do.	1909	5,000	Do.
1894	[c]165,000	Tributaries of Sunapee Lake.	1910	6,000	Do.
1896	50,000	Sunapee Lake.	Total	1,008,665	
1898	50,000	Do.			

[a] "Rangeley trout."
[b] Eggs taken at Sunapee Lake.
[c] 5,000 are stated to have been delivered at Newbury. It is uncertain where they were planted.

NUMBER OF COMMON TROUT, PROPORTION OF MALES TO FEMALES, AND NUMBER OF EGGS TAKEN BY THE UNITED STATES BUREAU OF FISHERIES IN SUNAPEE LAKE FROM 1904 TO 1911, INCLUSIVE.

Year.	Trout.	Males.	Females.	Eggs.
1904	82	41	41	99,000
1905	69	47	22	64,020
1906	181	82	99	253,344
1907	46	20	26	71,462
1908	47	31	16	22,940
1909	8	5	3	5,600
1910				
1911				

The records of the number of eggs taken each year are not consecutive. From 1893 to 1903, inclusive, there are 11 years of which no records seem to be available. The number taken in 1892 was, as previously stated, 125,000. In 1904 there were only 99,000 secured, but in 1906 the unprecedented number of 253,344 were secured. The average number of eggs to each fish indicates that the fish averaged a fairly large size. That year (1906) 181 trout, as previously stated, were caught; in 1907 the take dropped to 46, in 1908 to 47, and in 1909 to 8, and in 1910 and 1911 the catch amounted to practically nothing so far as the eggs obtained were concerned.

While there are no conveniently available records of trout taken by anglers in the past few years, the general impression is that they are now too scarce to gratify the angler more than very seldom, and it is plainly evident that not enough can be secured there at present to restock the lake. And this is in spite of the fact that the brooks still contribute to the lake a good many small trout.

Habits.—The trout is almost omnivorous, as fully, if not more so, than the pickerel. In lakes where smelt or other available fish abound it subsists largely upon those fishes. An 11¾-inch trout caught in August at The Hedgehog in 90 feet of water was gorged with larval smelts. In brooks the trout subsists largely upon insects but eats any other fish and even its own kind at times. A 5-inch male trout taken in Pike Brook in April had been eating smelt eggs and larval insects, and two other larger ones were found to contain partly digested adult smelts, the remains of which, in each instance, measured 4 inches.

On April 24, in a pool in Pike Brook, a trout 8 inches long, with protruding, apparently blind eyes, was found near the hatchery. It was probably a fish that had been hooked a few days previously and one eye injured by the hook, the injury or inflammation extending to the other eye. The trout when first hooked was a beautiful, bright colored, plump fish. At this time it was somewhat emaciated and very dark colored, probably due to blindness, and thus indicating that change of color in a fish may depend, to some extent at least, upon sight. It was interesting to note that its stomach contained a partly digested smelt, the undigested portion about 4 inches long, which must have been recently ingested.

Small trout from 3 to 10 inches long were observed in Pike and Blodgetts Brooks throughout the season, and whenever there was water in King Hill Brook some trout were observed there. It was stated by persons familiar with the brooks and their condition that all the trout left the brooks and went into the lake after the first heavy rains in November.

On August 18, in the pool near the hatchery in Pike Brook, a school of at least 60 or more trout from 2 to 9 or 10 inches long was observed and they were still there about November 1. On October 30 and 31 many trout were seen in the brook as far up as Alaria Springs, but on November 2 only a few trout, perhaps 6 or 7 inches long, seemed to be left in the pool and but few observed elsewhere. On November 3, a very rainy day, about 3 p. m., three trout 5 to 10½ inches long were found in an overflow pool in the beach formed by a rise in the brook that day. The brook was pretty high and running swiftly through the beach. In the evening a great many trout were seen running down and 30 or 40 were caught. A small percentage of them would range from 5 to 10 inches in length (but the majority were smaller), many of them spent fish. A 10½-inch trout was a spent female. The biggest run was early in the evening. The fish were descending head first. None was seen headed up brook except when startled, when they would sometimes run upstream. These trout evidently had not tried to get out of the shallow overflow, as there were two quick-flowing outlets.

On November 4 a few trout 5 or 6 inches long were seen in Big Brook and many in Little Brook at Blodgetts Landing, and on November 5 a few, perhaps 3½ to 6 inches long, were observed in Pike Brook below the hatchery, but none above as far as Alaria Springs.

No direct observations were made upon the spawning habits of trout in Sunapee Lake. From the foregoing quotations and notes it is seen that formerly the trout ascended the brooks to spawn. The principal brooks frequented were Pike and Blodgetts Brooks, especially the former. In the fish cultural operations of recent years the trout were taken along the shores, principally near the mouths of brooks and very seldom on the "Reefs." It is probable that even now the few trout that breed in the lake attempt to enter the brooks and failing that they deposit their eggs in shallow water along the shore. In evidence of this it may be stated that on October 19 a pair, a male of perhaps 2½ or 3 pounds and a female estimated at 2 pounds, was discovered in a slip in the boathouse at Blodgetts Landing, which is not far distant from the brook. The female, constantly attended by the male, swam slowly about. The position of the male in relation to the female was always above her so that he could swim over, barely touching or just free from her. He was never below or alongside. This relative position was maintained during the several observations made upon them during that day. On the 20th the fish had gone, probably having been disturbed by the frequent outgoing and incoming of a motor boat.

Size.—The trout varies in size according to the conditions of environment, in some waters attaining maturity when small and remaining small. In other places it grows rapidly, attaining a considerable size before maturity and reaching a weight of 10 pounds or more.

There seems to be very little that can be learned regarding the size obtained by trout in Sunapee Lake prior to the beginning of fish culture. In Forest and Stream of September 2, 1886, Dr. Quackenbos gives the following records of "largest trout" caught in Sunapee Lake, but no definite dates appear: George Farmer, of Newbury, one of 12 pounds, 30 years ago; J. C. Stickney, North Point, one of 10 pounds; Frank Jewett, Pike Shore, one of 9 pounds; Alvin Haskins, one of 7 pounds 14 ounces, in Pike Brook. Dr. Quackenbos states that the largest "couplet" that he had on record was 13 pounds, and the best sweep by the seine fishermen was in 1837, at Newbury, when 40 brook trout from 1 to 5 pounds each were taken in 15 minutes.

Previous quotations from the New Hampshire Fish Commission reports show that in 1883 trout were taken weighing from 1 to 6 pounds, and again in 1888 that the fish taken ranged from 1 to 7 pounds.

If the native trout in those early days attained a large size, there must have been abundant food, especially in the form of young and small fishes. Trout do not reach a large size on an exclusively insect diet, probably because such food is seldom sufficiently abundant to supply the required nourishment to a large number of fish. Where the chub and redfin occur, unless under unfavorable conditions, they are usually abundant, and it may be inferred that those species were once more plentiful in the lake and perhaps contributed to the size of the trout. Elsewhere in this paper it has been suggested that the white trout was once small, as was formerly the case with the blueback of Rangeley Lakes. If this hypothesis is true and the Sunapee "native trout" reached a large size prior to the advent of smelts, the small white trout might have formed its principal food, as the small blueback is said to have done to the Rangeley trout and to which fact was ascribed the noted large size of the Rangeley trout of years ago. However, after the introduction of smelts the records show that the trout grew to a large size and were numerous in the lake, but decreased in size and numbers, at first gradually, later rapidly, because of the poacher and introduced carnivorous fishes. The introduction of smelts then probably protracted the existence of the trout to some extent, as it furnished abundant, easily obtainable food, which on its part did little or no damage to other fishes. Whatever the cause, it is evident that the trout is now comparatively rare and does not attain the large size that it formerly did, because it does not have time before it is caught.

The smallest trout that the writer observed in the lake, or taken from it, was one of 9¼ inches in length, which was caught April 23, 1910, on live smelt bait, set over night at Curtis's Pier. Its stomach was empty. On August 16, 1911, one about 10 inches long that must have come up from the lake was seen in the mouth of Pike Brook in the beach below a fyke net that completely occluded the brook.

Stocking of the lake.—The habit of trout spawning in brooks whenever possible and that of the young remaining in them for some time indicates that the brooks afford the most natural conditions in which to plant young trout.

The fact that large numbers of trout descend to the lake late in the fall during or after heavy rains offers no unfavorable argument toward planting them in the brooks. Although small, the majority of the trout thus migrating seem to be adult fish. It is at the time of the year when the shore waters are cool and the fish are not, on account of temperature, obliged to seek the deep water with its attendant dangers. Trout fry undoubtedly remain in the brooks over winter and food for such small fish is far more plentiful in the brook than in the lake at that season. While fish, young or adult, require less food and feed less in the winter than at other seasons the fact that hatchery-bred fish are liberally fed up to the time they are planted would seem to indicate that they should be planted where they can obtain the most natural food in order that they may not suffer from the sudden cessation of food supply. It has been suggested that salmon fry planted in the brooks in the spring would produce more successful results than even larger fish planted in the lake in the fall. The reasons are the foregoing. To plant them in the lake in the spring would only subject them to further disadvantages in the way of hungry and voracious fishes. While food is plentiful enough in the lake during the summer the shallow water that the young salmonid would naturally seek is not only too warm but infested with enemies, as is also deep water to which they would be compelled to resort for sufficiently cool temperature. Disregarding the lack of food, the late fall is undoubtedly the best time for planting them in the lake, as then the shore waters are cool and comparatively free from enemies.

BLUEBACK TROUT (*Salvelinus oquassa*).

This species of trout was originally discovered in the upper lakes of the Rangeley chain and was described by Girard in 1854. It has always been considered as peculiar to the Rangeley Lakes, where it abounded in the early years, ascending a few streams in countless multitudes in October to spawn, and where it was caught in dip nets by the barrel and even by the cartload by the inhabitants, and cured for winter use. In the course of time the fish became so diminished in numbers that the commissioners brought about the enactment of a protective law for this fish which hitherto had never been protected, but it continued to decrease until the present time, when it is nearly, if not absolutely, extinct in those waters. The alleged cause of the decrease was the excessive and unseasonable fishing by the inhabitants of the shores of the lakes. But these people had fished in the same way and to the same extent for more than 50 and perhaps 100 years with no perceptible diminution in the number of trout.

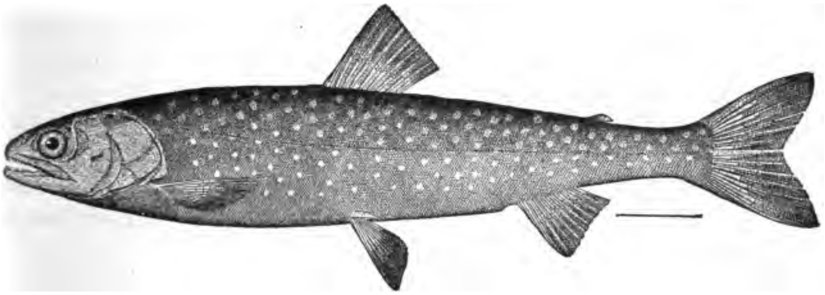


FIG. 2.—Blueback trout.

One of the first acts of the State fish commission after its establishment was to introduce landlocked salmon in the Rangeley Lakes. The diminution in numbers of bluebacks was in direct ratio to the increase in numbers of salmon. The salmon now abound in those lakes. The bluebacks are no more, and not only that, but trout have decreased in numbers notwithstanding the bounteous annual plants of young.

A curious phenomenon was connected with the disappearing bluebacks. The original blueback never attained a size over 9 or 10 inches in length, or much over one-fourth of a pound in weight. In 1895 the smelt was first introduced, and it increased in numbers rapidly, so that in 10 years these little fish fairly swarmed in the lake and in the spring breeding season they were washed up in windrows on the shore, much to the annoyance of those living near the shore, owing to the stench of rotting fish. After the introduction and increase in number of the smelts, occasionally a large blueback was caught on a hook, that is, a fish that would weigh a pound or more, and in the fall seasons of 1901 to 1904 in Rangeley Stream the few bluebacks that were found there by the State fish hatchery operations were all large ones, weighing from 1 to 2 pounds or more. Since then no bluebacks, to the writer's knowledge, have been taken in Rangeley waters, and he has endeavored to keep in touch with the matter. The increase in size of the few remaining bluebacks is ascribed to the smelts upon which they probably subsisted.

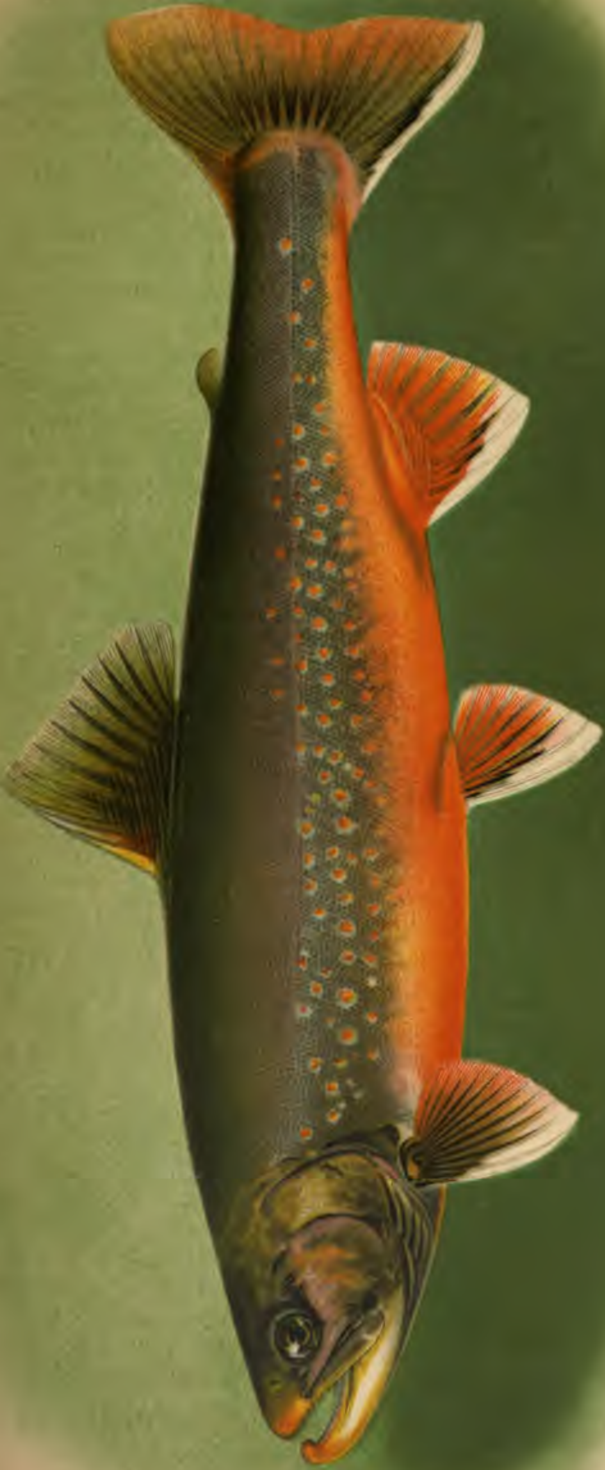
The reports of the State fish commissioners of New Hampshire indicate that on April 26, 1878, 3,000 and again on June 3, 1879, 4,000 young bluebacks were planted in Sunapee Lake.

They have never given evidence of their presence in the lake, unless the white trout of that lake are the results of those plants, which was at one time contended by some. This will be discussed in connection with the latter.

WHITE TROUT (*Salvelinus aureolus*).

Description.—The "white trout" of Sunapee Lake is one of that group of salmonid fishes properly known as charrs, of which, in this country, the common trout (*Salvelinus fontinalis*) is the best-known member. It is closely related to, if not specifically identical with, the European charr otherwise known in this country by the German name "saibling" (*Salvelinus alpinus*), and very close to the only charr occurring on the Pacific coast of the United States, *Salvelinus bairdii* (*S. malma* Jordan and Evermann in "Fishes of North and Middle America").

The Alpine charr occurs throughout central and northern Europe, to some extent in the British Isles, as nominal species, varieties or forms of *Salvelinus alpinus*, and in closely related or identical forms in Spitzbergen, Iceland, Greenland, Arctic North America, and Siberia. Many forms of the saibling have been described as distinct species, but the supposed distinctive characters, upon study of an increased amount of material, have been found to be only individual variations. On the other hand, some forms have been found to possess differences that are group variations more or less local in character which may be of specific value.



WHITE TROUT. BREEDING MALE.

The difficulty with which such value is determined among these fishes, however, is well illustrated in the case of the white trout of Sunapee Lake, which was at first and at the same time pronounced by two eminent ichthyologists to be the common trout. Later by one it was said to be the European saibling, and by the other the blueback trout of Rangeley Lake, some of which had been planted in the lake. The latter at that time considered the "blueback" identical with the saibling forms occurring from New England through Quebec, Labrador, and Greenland, but possibly not indigenous to Sunapee Lake. The other stoutly maintained that "the affinities of this form are closer to the saibling by the way of an Atlantic steamer than by way of Greenland and Iceland." The same form, however, was known in Floods Pond, Me., long before the saibling eggs from Europe were received in this country. Again, the second-mentioned authority later pronounced the Sunapee white trout a species new to science and described it under the name of *Salvelinus aureolus*, and the first authority described two smaller forms as *Salmo* (*Salvelinus*) *agassizii* and *Salvelinus marstoni*, respectively. On top of all this one of the most distinguished ichthyologists in this country, and one with whom the describer agreed, decided that *S. agassizii* was only a local variety of the common trout (*S. fontinalis*), notwithstanding not only its difference in shape and color, but the fact that it was said to possess teeth on the "hyoid bone," or "root of the tongue," a difference that was supposed to distinguish the saibling forms from the common charr (*S. fontinalis*).

Notwithstanding the absence of prominent structural differences, there is a question whether it is not well to recognize slight differences of that kind in connection with those of size, color, and habits, at least locally constant and fixed. It has been said that species are not entities and that the term is only an expression of our ignorance. So it might be said of many other things and terms. The writer can not subscribe to this view, but regards the use of specific as well as other terms used in classification as expressive of what is known.

Classification is not wholly theoretical and of use to the taxonomist alone. It is of practical use to the fish culturist. It is of value to him to know that one form attains only a small size and ascends streams to spawn, and that another form reaches a weight of 6 to 8 pounds and spawns on shoals in the lake, and to have names by which to distinguish them. From the fish-cultural standpoint, based upon what is known of the fish, these two forms are or should be regarded as distinct species in order that the fish-cultural distribution may be rational. But if the transfer of the one form from its habitat to the habitat of the other results in the change of the structure, color, and size of the fish to that of the occupant of the water to which it is transferred, the distinctive names are no longer of any use. A knowledge of the conditions of the respective habitats alone becomes essential to the successful results in the fish-cultural distribution of the fish.

It is therefore very desirable for fish culturists to know whether the comparatively insignificant little bluebacks of Rangeley Lakes transplanted into Sunapee Lake became the large, important food and game fish of the latter lake. The protracted and animated discussions of this question in various sportsman's journals and other publications never settled the question, nor can it ever be positively determined. All that can be done now is to deduce approximate probabilities from the known facts bearing on the matter.

Occurrence in Sunapee Lake.—The reports of the New Hampshire Fish and Game Commissioners indicate that on April 26, 1878, and again on June 13, 1879, 3,000 and 4,000 young bluebacks were, respectively, planted in Sunapee Lake, surely a small number from which to expect immediate extensive results.

According to Dr. John D. Quackenbos,[a] as far as is known the first specimens of this new fish to be distinguished from the well-known forms were taken in Sunapee Lake during the summer of 1881.[b] The fish taken weighed from 2 to 3 pounds each. Dr.

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[a] The Sunapee Saibling: A fourth New England variety of *Salvelinus*. Transactions New York Academy of Science, vol. XII, 1893, p. 140.

[b] In Forest and Stream, Dec. 18, 1890, p. 435, Dr. T. H. Bean adduces evidence that the white trout is indigenous to the lake, from information furnished him by Commissioner Hodge. Commissioner Hodge was an earnest advocate of the idea that it was native and the various disputants discredited this evidence. While it has not been admitted in the discussion of the trout in this paper as positively authentic, it is in line with what has been stated regarding what usually occurs when a strange fish is discovered (p. 124). Dr. Bean writes:

"During a visit to New Hampshire, in October of this year, the writer first met his friend and correspondent, Col. Elliott B. Hodge, a gentleman whose name is throughly identified with fish culture and protection in the State which he loyally serves as fish and game commissioner. We were at Plymouth and Sunapee Lake together, and discussed many objects of mutual interest, among them the golden trout, which Col. Hodge first brought to the notice of ichthyologists and which was introduced to the general public through the columns of Forest and Stream. From him I learned many interesting things relative to the history and habits of the new trout, and, as they have an important bearing upon the inquiry now being made into the relationship of the golden trout to the introduced saibling, I think this an opportune time for making the information public.

"Mr. Pike, who was born and brought up at Sunapee Lake, says that about 25 years ago he and his father saw a great school of trout in the lake. They caught a good many of them, but never looked for them again, because they supposed it to be a mere chance occurrence.

"Mr. Nat. Lear, of Newbury, N. H., told Col. Hodge that when they were building the Concord & Claremont Railroad, in 1872, shortly after the introduction of smelt, he and some others were catching smelt at the mouth of Beech Brook one night (this brook is a tributary of Sunapee Lake), when they saw what they supposed to be a large sucker and dipped it up. It proved to be a white trout of 4 pounds, and looked to him, as he remembers it, just like the *aureolus*, which he has seen since. It was very white and silvery.

"Mr. Moses Gould, of Bradford, N. H., who was one of the earliest trout fishermen on the lake, and fished from boyhood, claims that in 1873 he caught two large trout of this kind in Sunapee and showed them to a number of persons as a very peculiar trout.

"About 1873 or 1874 Thomas Roach caught two trout through the ice in Sunapee, one of which weighed more than 7 pounds. Up to 1871 Sunapee Lake was practically unknown as a fishing lake for trout, and there were scarcely any boats on the lake. The little fishing that was done was chiefly for pickerel. No one fished in deep water for trout until their accidental discovery in great depths about 1881 or 1882. The *aureolus*, being a very late spawner, came onto the shoals at a time when there was little or no travel across the lake.

"A Mr. Peabody stated that in 1881 or 1882 he saw a big school of suckers on the shoals south of Loon Island, Sunapee Lake. Of course there is little doubt that these were golden trout."

Quackenbos states (loc. cit.) that in the two following years, 1882 and 1883, a sufficient number were taken to excite comment. In October, 1885, Col. Elliott Hodge, then State fish and game commissioner of New Hampshire, had his attention called to the fish, accidentally discovered in vast numbers on a "mid-lake rocky shoal." He wrote to Dr. Quackenbos: "I can show you an acre of these trout, hundreds of which will weigh from 3 to 8 pounds each. I could never have believed such a sight possible in New Hampshire."

Thus it appears that three years after the first lot of bluebacks were planted specimens were taken weighing 2 and 3 pounds and still more and larger ones in the next few years. In five or six years at most they occurred in prodigious numbers, "hundreds of which would weigh from 3 to 6 pounds each."

Taking into consideration the probable abundance of food in the form of smelts, it would not be surprising that in 6 years the fish might attain 6 pounds or more in weight, allowing an average increase of 1 pound to the year, which is a stated estimate for the common trout under favorable conditions. But when the abundance of predaceous fishes like the common trout, landlocked salmon, perch, and others, are taken into consideration, it might be doubted that in that length of time such a multiplication of the species would result from such a small plant as 7,000, even under the most favorable of other conditions, especially when the extinction of the blueback in the Rangeley Lakes, as has been pointed out, is doubtless due to landlocked salmon.

The Rangeley blueback has been planted in various other lakes of Maine and New Hampshire where the conditions were apparently fully as favorable for it as Sunapee Lake, and none has since been reported. This, however, does not prove that Sunapee is not an exception, but is collateral evidence. Furthermore, the same white trout has been discovered in other New Hampshire, Maine, and Vermont waters where no red, white, or blue trout has ever been planted and where they could not gain access from their native waters save through the instrumentality of man; and it is not impossible that it may yet be found in waters where it is not at present recognized. The later discoveries just referred to do not prove that the Sunapee white trout did not result from the blueback introduction, but are evidence to the contrary, showing that there is no necessity to account for its presence in Sunapee Lake by man's intervention. There is no record of the introduction of any other fish than the blueback which could possibly account for its presence. It has been absolutely proved that none of the products of European saibling eggs ever reached Sunapee Lake. If not a blueback or a saibling, and not indigenous, where did it come from?

The fact that it was "never observed" prior to this time may be a matter of not recognizing it as distinct from the common trout, or as Dr. Quackenbos suggests (loc. cit.), "in the ignorance of the few who in old times may ever have seen it, and who cared for nothing beyond the fact that it was good to eat."

It is quite possible that before the smelts were introduced the Sunapee white trout was small like the blueback of Rangeley Lakes, on that account never taking the hook and never observed, as it did not ascend the brooks to spawn; and that, like that species, it did not attain a large size, until after the introduction of smelts, owing to scarcity of food conducive to such growth. But there is no way to prove this.

That a fish may exist in a body of water for many years without becoming generally known is not so strange as at first thought it seems. Many resident fishermen and even nonresident anglers have caught at times fish that were more or less strange in appearance. In such cases they discuss the identity among themselves and perhaps come to the conclusion that it is a freak form of some other fish, which it to some extent resembles. When not accounted for in that way it is usually ascribed to hybridization, or if a fish with which they are not familiar has been introduced it is likely to be considered that form. But seldom is it suggested that it is a hitherto unrecognized species, and usually instead of sending it to some competent authority for identification it is taken home and eaten or given to the cat or hens. But when some more observing person detects a hitherto unrecognized fish, many others remember that they have caught the same thing at one time or another. Of course there are instances of forgotten or accidental introductions of fish which when discovered can not be definitely accounted for, but in most instances such can be determined. The white trout, for instance, was at first thought by some to be the result of a plant of some fish from the St. Johns River, an account of which is given by Dr. Quackenbos (loc. cit.). But it is well known that no such fish occurs in the St. Johns River, and it was finally decided that the supposed St. Johns River fish were landlocked salmon from Grand Lake stream, Maine.

Habits and food.—The habits of the American saibling are essentially like those of their European congener. They are what may be termed deep-water fishes, at least in the southern part of their geographical range, occurring in shallow water, as a rule, only when the water is cool, principally in the fall breeding time and early spring. Occasionally in summer one may be seen at the surface in early evening or on a cool, cloudy day, but it apparently does not remain there long. Such appearances at the surface seem to be on account of insects upon which the fish occasionally feeds.

Deep water in this section is affected undoubtedly on account of its coolness, as in the far north the fish are found not only in shallow lakes but in streams. The saibling of the far north and as far south as southern Labrador and Newfoundland, and perhaps the north side of the Gulf of St. Lawrence, in common with the "brook trout," has sea-run forms, as have the saiblings (*S. bairdii* and *S. malma*) of the Pacific. In fact, in those regions they are best known as "sea trout."

That the "sea-running" habit is not possessed by the more southern forms is easily accounted for by the remoteness of their habitats from the sea and the obstructions in the waterways.

The food of the different forms varies according to locality and size of the fish. In localities where fish are suited to their maw and taste, such form their principal sustenance. They feed to some extent upon insects, especially the larval or aquatic forms.

An article by S. Garman in a sportsman's journal in 1891 says: "In New England the habits of the saibling would seem to be the same as on the other side of the Atlantic. Of such as were examined the stomachs were filled with small fishes, mainly smelt, and in several cases with spawn."

The larger white trout examined by the writer at Sunapee Lake always contained smelts when there were any stomach contents at all. Several ranging from 5½ to 8¼ inches in length caught at The Hedgehog in about 90 feet of water also contained smelts.

The following observations on very young white trout were made in 1910. April 23, along the shore of Soo-nipi Park, principally over coarse gravel and over sand beach near the gravel, several young were seen and four of them caught, each about 1 inch long. When disturbed they would swim and dart about, hesitating to go far into deep water. But if they went toward shore they would not conceal themselves under the gravel, but seemed to depend for protection upon darting and dodging, at which they were quite adept. Apparently becoming tired, however, they swam more slowly and were easily caught. Their stomachs contained larval diptera (*Chironemus*) and some minute crustaceans (*Entomostraca*). April 28, at the head of Pike Brook deadwater, eight specimens 1 to $1\frac{7}{16}$ inches long were caught. Their stomachs also contained principally *Chironemus* larva.

The breeding habits also vary, as they do in the European saibling. Some forms ascend streams in the fall to spawn, others spawn upon shoals in the lakes.

The white trout of Sunapee Lake, during the summer months, resides in depths of from 60 to 90 or 100 feet, where the temperature is in the neighborhood of 50° F. or less. In the spring it occurs in shallow water about the shores and is often caught from the wharves and piers. In the early part or middle of October it appears on a shoal near the entrance to Sunapee Harbor, to spawn, and the run continues approximately one month. This seems to be the only spawning place in the lake. At least, in the search that has been made for other grounds, none has been found.[a] This is the shoal where the fish was discovered in such numbers by Commissioner Hodge. The shoal consists of coarse gravel and sand thickly interspersed with bowlders of various sizes, and, as has been previously mentioned, is contiguous to deep water. The water on the shoal varies, of course, with the level of the lake, but it averages from a foot to 6 or 8 feet in depth in places. A phenomenon was noticed on the shoal which may account for the peculiar suitability of the place for a spawning ground of the fish; that is, whenever a light breeze is blowing from any quarter, even from the side most protected from the wind, there is always a perceptible current across the reef, and at times quite strong, in the same general direction of the wind. The temperature of the water at the beginning of the breeding season is from 40° to 45° and later about 33°.

In the spawning runs males at first predominate. The action of the fish on the ground has not been fully observed, or, if observed, has not been described. Such observations, however, are difficult, owing to the fact that the runs occur at night.[b]

The following table shows catches by night on "The Reef" during the month of October, 1910, showing the proportion of males to females:

Date.	Total.	Males.	Females.	Date.	Total.	Males.	Females.
Oct. 21	7	6	1	Oct. 29			
23	12	11	1	30	46	6	40
24	49	37	12	31 Nov. 1	30	2	28
26	40	30	10				
27 28	96	51	45				

Up to the 29th females were in the minority and during the latter part of the month greatly predominated. This may be due to the fact that the males running first were nearly all caught.

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[a] In the American Angler of Feb. 19, 1887, Dr. Quackenbos stated that in the previous fall the "oquassa trout," as he termed it was observed to attempt ascent of the inlets in company with the common trout.

During the search for other spawning grounds of white trout on Oct. 18, 1910, two individuals, of one-half and 1¼ pounds, respectively, were taken in gill nets set near the mouth of Pike Brook, and on Oct. 8 and 9, 1911, a pair, male 4 and female 5¼ pounds, was caught in gill nets sunk to the bottom in about 30 feet of water, in Blodgetts Cove not very remote from the brook.

[b] In Forest and Stream of Dec. 18, 1890, quoting Commissioner Hodge, Dr. Bean says: "The golden trout have sometimes come on the spawning shoals by the ton at a time. They do not pair to any noticeable extent, and a female is sometimes attended by five and six males. They make no nest, but move around continuously like lake trout. The lake trout voids the eggs by rubbing the belly over the coarse rocks, and the males sometimes lean down on top of the females. At Loon Island shoals the fish have spawned in waters so shallow that their backs were not covered. The usual depth ranges from 6 inches to 4 or 5 feet, but some of the large ones doubtless spawn in deep water."

A female is stated to average about 1,200 ova to the pound of fish. From fish-cultural operations it is observable that the eggs are not always deposited at once, more than one and sometimes several strippings being required to get all of the eggs. While this may possibly be due to the abnormal conditions incident to their retention in live cars, it is probably a natural condition.

It is stated that white trout have been taken weighing as high as 8 and even 10 pounds, but the largest of authentic record known to the writer was 7 pounds. The average size of those taken by the Bureau fish culturists in the fall of 1911 is estimated to be about 1 pound, but there were some much larger and many considerably smaller than this.

It is not known how long after hatching the young remain upon the shoal, but in summer young white trout of only a few inches in length are taken on the same grounds with the large fish.

Culture.—In the reports of the State commissioners no comments are made regarding the spawning of white trout until the report of 1889, where it is stated that 200,000 were planted in May and June, and "the aureolus were late in coming on their spawning beds; still a fair number were taken, considering the weather." The report for 1890 says that the fish came on their spawning grounds early in October and that 100,000 eggs were taken. The report for 1891 says: "The aureolus came on their spawning beds in October in large numbers and many more were secured than last year." The report for 1893 has the following: "Of the aureolus more than twice the number were taken [than last year], 148 having been procured in one day. Owing to the fact that a large percentage were male fish, the amount of spawn taken was but little over twice that laid down last year, being 105,000 last year and 218,000 this year."

The succeeding reports state in tables the number of fish planted and distributed. From these reports it appears that the State commission took the first white trout eggs in the fall of 1887 and made the first plant, as previously mentioned, in 1888. The State commission operated at Sunapee Lake until about 1900, and in that time planted 985,000 fry. In 1902 the United States Bureau of Fisheries assumed the work as a field station. The first plant was made by the Bureau in 1903, and the operations were continued until 1911. The detailed lists of distribution in the reports of the Bureau show that in this time 1,079,873 young white trout, mostly fry, were planted in the lake. There are several years of which the State reports give no records, presumably because no fish were planted.

The table following shows the plants of fry in each year by the State and Federal hatcheries.

BY NEW HAMPSHIRE.	
1888	200,000
1889	250,000
1891	70,000
1892	105,000
1894	200,000
1897	70,000
1898	90,000
Total	985,000

BY BUREAU OF FISHERIES.	
1903	[a]21,025
1904	16,000
1905	157,499
1906	213,163
1908	191,736
1909	229,736
1910	171,029
1911	79,685
Total	1,079,873

In 1890, 90,000 were planted by the State in other waters but none in Sunapee. The total number planted in Sunapee Lake from 1888 to 1911, inclusive, according to these figures, is 2,064,873.

The records of Mr. James D. De Rocher, of the United States Fisheries station at Nashua, who has been in charge of the Sunapee Lake field station since 1904, show the catches of white trout in each year as indicated in the following table:

CATCHES OF WHITE TROUT IN SUNAPEE LAKE.

Year.	Total trout.	Males.	Females.	Eggs taken.
1904	360	207	153	275,000
1905	721	461	260	349,800
1906	770	500	270	374,400
1907	614	395	219	290,786
1908	655	390	265	372,084
1909	374	164	210	302,050
1910	300	171	129	195,650
1911	706	416	290	370,300
Total	4,500	2,704	1,796	2,530,070

It is variously claimed and disclaimed that the white trout are increasing in number. There was a great falling off in the catch of 1904 over previous catches by the State commission, but this may have been due to imperfect or incomplete methods of catching them, or bad weather. In 1905 the catch about doubled that of the year before. In 1906 there was an increase of 49. In 1907 it fell off 56, but rose again in 1908 by an increase of 41 over 1907. In 1909 it dropped again to 281 less than the year before and in 1910 to 74 less than 1909, but 1911 brought it up to within 64 of the 1906 catch, the largest of the eight years. Yet there was a vacillating decline from 1906. The increase in 1911 was encouraging, as it possibly indicates an increase that may be maintained. But if the fish are increasing in numbers they are decreasing in size. It is only necessary to refer to the commissioners' reports of the early status of this fish in Sunapee Lake and compare it with Mr. De Rocher's statement, supported by his records, to substantiate this view.

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[a] Includes 4,200 fingerlings.

Mr. De Rocher states that when he first took up his work there the fish would run 2 and 3 pounds on the average and larger ones up to 7 pounds were often caught, but now they do not average over 1¼ pounds, although some larger ones are still taken.

An increase in numbers is possible through the larger numbers planted and the decrease in the number of landlocked salmon. But the chinook salmon is a menace. A number of instances are reported where small white trout have been found in chinooks' stomachs. That this salmon has had no very apparent effect upon the trout is probably due to the comparatively recent increase in numbers and size of the chinook. The writer ventures to predict that if the chinook continues to increase in numbers the white trout will again decrease. The same may be said of an increase in the number of landlocked salmon. This has been discussed in another place and need not be repeated here.

Characteristics.—All of the saibling group are readily distinguished superficially from the common or "native" trout by the absence of rivulation on the back and usually by the more slender form. The common trout at all ages possess the rivulations. The presence of basibranchial or so-called "hyoid" teeth also is a distinguishing characteristic in New England, but farther north, as in Labrador, a fish supposed to be *S. fontinalis*, having the rivulations or wavy bars on the dorsal and caudal fins, at least has been found to have teeth on the "root of the tongue" or basibranchials. This is the case with the type specimens of *S. hudsonicus*, and this form (*S. hudsonicus* Suckley or perhaps more correctly *S. canadensis* Hamilton Smith) on that account, perhaps, should stand as a good species or, if intergradations are found, at least as a subspecies.

While it is comparatively easy to distinguish the common trout from the saiblings, it is rather a difficult matter to distinguish the species of the group. If they were not so closely related, it would have been easy to decide whether the Sunapee white trout was a Rangeley blueback or not. Dr. Bean distinguished *Salvelinus aureolus* from *S. oquassa* by the following differences:

SUNAPEE TROUT.	BLUEBACK.
1. Anal III, 8	Anal III, 10.
2. Immature 9 inches in length	Mature 9 inches in length.
3. Color of back in young, numerous dark blotches	Back uniform steel blue.
4. Embryo with white lines at the upper and lower edges of caudal.	No such white lines.
5. Spawns in lake on shoals	Spawns in streams.
6. Gill rakers shorter and usually less numerous and almost always curled.	More numerous and not curled.

The first difference will not serve to distinguish, as *S. aureolus* sometimes has 10 anal rays, but in general it is of significance, especially when taken with other apparent differences, that the usual anal-fin formula in *S. aureolus* is 9, that of *S. oquassa* 10 or 11.

The second distinction does not now obtain, for mature 9-inch *aureolus* have been observed and *oquassa* is known to reach the size of the average *aureolus*.

The third is of no value, as it is comparing an immature or young fish with a mature adult.

The fourth is of little value, as it refers to a character that was observed in *S. aureolus*, but its absence in *S. oquassa* was conjectured.

Fifth. The place of spawning is obviously not a specific distinction.

Sixth. The gill rakers of the large specimens of *S. oquassa* do not differ in number, length, or in curling and other distortions from the Sunapee white trout.

Having weighed and found most of these supposed differences wanting, it remains to point out the real differences, if any exist. The most conspicuous external difference is of color, and that is not very pronounced. The spots are more numerous and smaller, and the under side of the pectoral fin has a narrow margin of white in *oquassa*. While, as before stated, the *oquassa* occasionally has as few as 9 rays in the anal, it more often has 10 or 11, and *aureolus* never has been found to have 11, and only rarely 10. Comparing two male specimens each of the two species, the *oquassa* apparently has a somewhat longer head and snout. More careful examination of a larger number of specimens each might either reveal more differences or reduce the foregoing to naught. The young, even in the fry stage, are usually easily distinguished from the common trout by fewer parr marks.

Propagation.—The European saibling has been successfully cultivated for many years, and judging from the experience in hatcheries in Maine, as related by Mr. Merrill in a letter to Dr. Quackenbos,[a] the young of the white trout could be easily reared to yearlings, if desired, in artificial inclosures. Mr. Merrill states:

> At Green Lake the temperature of the water runs high in the spring, and much loss has been occasioned thereby among the brook trout fry, but the saibling have in such cases remained perfectly healthy. My experience in rearing this fish has been extremely satisfactory, and I believe it to be one of the best subjects for the fish culturist among our Salmonidæ, especially where the fry are reared to the yearling stage, as is generally done in Maine. The eggs that I received last winter hatched well, and the fry in the early stages of development displayed wonderful hardiness under the most trying circumstances.
>
> The brook trout during the spring suffered from warm water, the temperature rising to 65° F. soon after they hatched. The loss was considerable, but the saibling fry were not affected by this high temperature. * * *

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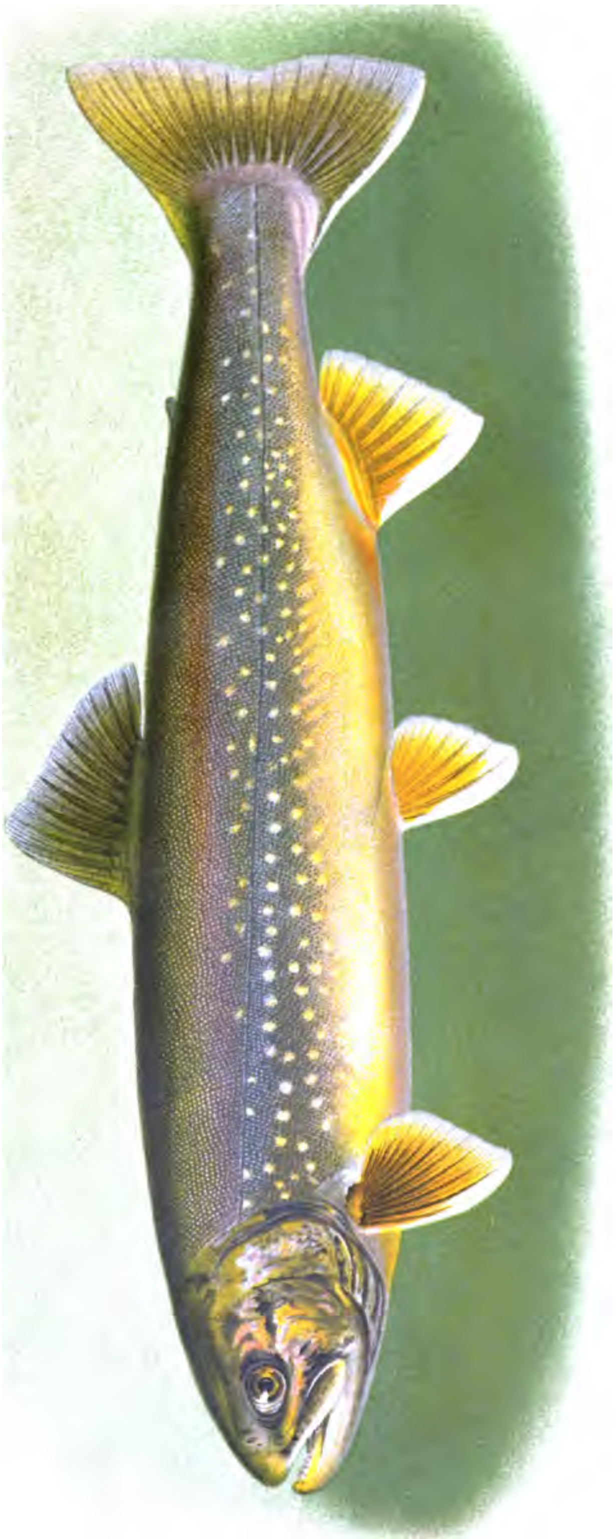
[a] "The American Saibling," etc. Second Annual Report of the Commissioners of Fisheries, Game and Forests of New York for 1896, p. 185-191.



WHITE TROUT. BREEDING FEMALE.

In consideration of the experience which I have had with the American saibling, I would select it in preference to any other fish if I desired a salmonoid to rear from fry and obtain the best results in size and percentage matured.

GRAYLING (*Thymallus montanus*).

The Montana grayling originally existed only in the tributaries of the Missouri River above Grand Falls. The United States Bureau of Fisheries first began successful propagation of the grayling in 1897, at Bozeman, Mont., under the superintendency of Dr. James A. Henshall. It was at the Bozeman station that the grayling planted in Sunapee waters originated. The habits of this grayling are described by Dr. Henshall as follows:

> The Montana grayling prefers swift, clear streams of pure water, with gravelly or sandy bottom. It is quite gregarious, lying in schools in the deeper pools, in plain sight, and not, like the trout, concealed under bushes or overhanging banks. In search of food, which consists principally of insects and their larvæ, it occasionally extends its range to streams strewn with bowlders and broken rocks. The fry subsist on minute crustaceans, as *Entomostraca*, and for seizing the minute organisms is furnished, like the lake whitefish fry, with two sharp retrorse teeth in the upper jaw.

The grayling spawns on gravelly shallows, and Dr. Henshall says that it will go long distances, if necessary, to find suitable spawning grounds, even passing through large lakes to the inlets.

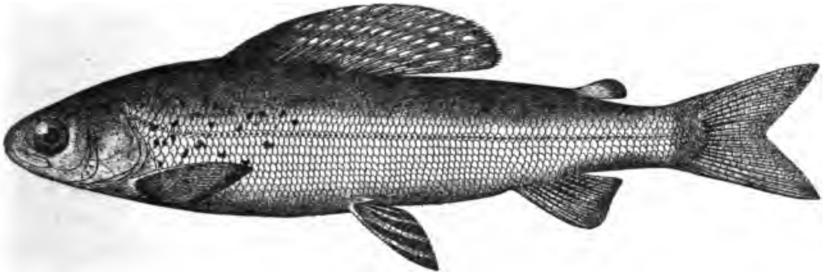


FIG. 3.—Grayling.

Regarding its game and food qualities, Henshall is quoted as follows:

> The Montana grayling is a most graceful and beautiful fish, whose dainty and lovely proportions and exquisite coloration must be viewed fresh from its native waters to be appreciated properly. As a food fish it is fully as good as the trout, and to my taste better. Its flesh is firm and flaky, very white, and of a delicate flavor, as might be expected. As a game fish it is the equal of its congener, the red-throat trout, and when hooked breaks water repeatedly in its efforts to escape, which the trout seldom does. It takes the artificial fly eagerly, and if resisted at the first cast will rise again and again from the depths of the pool, whereas the trout will seldom rise the second time to the same fly without a rest.

The United States Bureau of Fisheries reports of the distribution of fishes show that the following plants of grayling were made in Sunapee waters: In the tributaries of Sugar River, in 1904, 10,000; in 1906, in Sunapee Lake, 15,000; and again in Sunapee Lake, in 1907, 40,000, aggregating 65,000. There is no evidence that these plants were successful.

Sunapee Lake and Sugar River are surely not suitable waters for the fish, according to Dr. Henshall's statement regarding its requirements. The conditions of the tributaries of Sugar River referred to are not known to the writer. Should the grayling become acclimated in these waters, it could hardly do any harm, as it is mainly an insect feeder, and does not attain a large size.

SMELT (*Osmerus mordax*).

The common smelt is primarily an anadromous marine fish, the geographical range of which is from Labrador south at least to New Jersey, and it has been recorded from the Delaware.

It abundantly ascends the St. Lawrence River, the rivers of New Brunswick, Nova Scotia, Maine, and New Hampshire, to some extent the streams of Massachusetts, Rhode Island, Connecticut, New York, and formerly New Jersey, especially in the latter State the Raritan and Passaic Rivers. Even now brooks of Long Island are said to be frequented by smelt.

The smelt is of considerable commercial importance throughout its present geographical distribution, as caught in traps, weirs, seines, and in the winter through the ice with hook and line. Throughout its range, at least as far southward as Massachusetts, it has become landlocked; that is, in times past, some have remained in fresh-water lakes and ponds and formed a fresh-water race, which in breeding time continues its anadromous habit of ascending tributary streams whenever possible, from its fresh-water sea. In a few ponds, however, it spawns along the shores among the sedges and water plants. It has even been claimed that smelt eggs have been obtained from deep water, attached to sticks. This, however, is probably due to a mistaken identification of the objects.

Fresh-water races.—In many lakes there are apparently two distinct races of smelts, which possibly may be distinct species. In fact, the fresh-water smelt may be specifically or subspecifically distinct from the marine form, or there may be many distinct species in fresh waters, as a number of lakes produce smelts which, in the absence of sufficient material examined, seem to differ from the smelts of other fresh waters. Cope long ago described two Maine lake forms as distinct species, which have since been recognized in the books as subspecies of the marine smelt. But the differences are sufficient to constitute distinct species, at least until intergrading forms have been discovered.

Therefore it is possible that the fresh-water smelts should all be considered one or the other of Cope's species; but inasmuch as one of these, at least, differs from some other fresh-water smelts as much as it does from the marine smelt, it seems more likely to confuse than to clear up the matter to transfer and apply names indiscriminately without sufficient data upon which to base conclusions.

The two apparent fresh-water races, previously alluded to, may be only apparent on account of this same lack of knowledge. The apparent differences are those principally of size and habits and to some extent structure, so far as examination of specimens has proceeded. In a number of Maine lakes there are (apparently) two distinct sizes, with somewhat different breeding and feeding habits. One size reaches a length of at least 15 inches and a weight of a pound, and even larger ones have been reported. The smaller one existing in the same lake seems not to reach a larger size than 5 or 6 inches at most, as indicated by those constituting the breeding runs in the streams. The time of spawning differs more or less. The height of the period of the larger form being at least a month earlier than the smaller one. The smaller one usually ascends the streams as soon as they are free from ice, or a little later. The larger one is known to ascend them, in some localities at least, before the ice is out.

In those lakes where there is apparently such an extreme difference in size, only the larger form is caught with hook and line in summer and through the ice in winter, this being due to the difference in feeding habits, the large smelt subsisting mainly upon smaller fish, for the most part young smelts and the smaller form. The small smelt subsists, so far as at present ascertained, almost wholly upon minute crustaceans. This characteristic feeding habit obtains, however, only where the two apparently widely distinct forms exist, as in some lakes, Sunapee for instance, even little smelts only 4 or 4½ inches long are taken on worm and fish bait.

Then, again, there are lakes and ponds where the two distinct sizes do not seem to exist and the smelts are of practically a uniform size in the one pond, differing in size variously from those of other ponds, according to the pond; and some of the ponds are closely connected with lakes in which the two sizes exist, others are far remote from other ponds with smelts.

Some of the large and deep lakes contain only tiny, transparent smelts, sexually mature when only 2 or 2½ inches long; while in a neighboring body of water, at least within the same county, a much smaller pond contains smelts 6 or 8 inches long. Also there is an instance of a very large lake containing the two apparent extreme sizes, with a tributary pond, the connecting stream of which is not over one-half mile long but at present obstructed by a dam, in which the smelts are uniformly of from 2 to 3 inches in length and sexually mature. Thus it appears that the smelt question is at present a very puzzling one, especially regarding their specific identity, and they afford a good example of the importance to fish culture of accurate classification. If the large smelts are specifically distinct from the small ones, and will attain a large size wherever successfully introduced, and the small ones, when transferred to any larger lake, or one of more suitable conditions for growth, do not attain a large size, the purpose of the transplanting will decide which form to select and propagate. If the fish is desired as a commercial food fish, without regard to the possible consequences to other fishes, the large form should be chosen. If a food supply for Salmonidæ or other game and food fishes is desired, the small form would be the proper one.

It may be said, however, that further investigation may show that all of these differences of sizes, feeding, and breeding are simply due to the peculiar conditions of the lake in which the smelts occur, and that the young of the large form planted in one body of water might not attain to more than the transparent 2 or 3 inch size, and the young of the latter size transplanted into another lake might reach the 12 to 15 inch size. There are a few instances of smelt occurrence that tend to support this. One large lake in Maine containing the two extreme sizes of 4 to 6 inches and from 10 to 15 inches in length has two tributary bodies of water in which smelts occur. In one, previously mentioned, a pond of an area of something over 1 square mile and a greatest depth of 30 or 40 feet, the smelts are not over 3 inches in length, and in the other, a much larger and deeper pond, receiving the waters of two other large ponds, there are again two sizes of smelts, the larger size, however, not growing as large as in the main lake. The smelts in these two tributary waters, on the theory that the fresh-water smelts are derived from the marine form and not vice versa, doubtless originated in the smelt of the main lake, which itself originated in the smelt that ascended from the sea. Yet, in the absence of positive knowledge, it is best to regard the foregoing apparent conditions and attendant possibilities in the propagation and transplanting of smelts.

The only waters in New Hampshire of which there is record of indigenous fresh-water smelt are Winnepesaukee and its connected waters. From these waters the smelt has been successfully introduced into various other New Hampshire lakes and ponds. It is stated regarding the smelt of these original waters that this peculiar condition exists: namely, while in Winnepesaukee itself the smelt is seldom over 4 inches long, in the tributary smaller ponds it attains a length of 6 or 7 inches or more.

Habits.—The fresh-water smelt in the summer months affect rather deep water, or cool water, which in the larger lakes varies in depth from 60 to 100 feet or such a matter. It does not thrive in shallower ponds unless the water is cool enough for them, but is known to occur in ponds not over 30 or 40 feet in depth.

As has already been stated, the food of the smelt varies according to the size of the fish, and it may be added, according to age. Its strong sharp teeth on the jaws and tongue indicate its carnivorous propensities, while its comparatively close-set gillrakers suggest rather minute planktonic food at certain stages of its growth at least.

The young subsist largely upon animalcules, such as minute crustaceans which usually abound in most fresh waters. The larger smelts appear to eat small fish and principally their own young, excepting in the smaller sizes of adults previously referred to.

While the smelt inhabits the deeper, cooler waters most of the year, it occasionally comes to the surface on calm cloudy days or in the edge of the evening and moves about in various sized schools, often with noses out of the water, frequently leaping from the water or rolling out porpoise-like. So far as has been observed, however, it is only the young and smaller sizes that do this. The significance of this habit is not known. It may be, as suggested by the size of the fish, for feeding, as it is under just such conditions as exist when smelts school that minute Crustacea, etc., are particularly abundant at the surface.

The writer never observed smelts in Sunapee Lake schooling at the surface in this way and could not learn that others had observed them. The fact that, as previously mentioned, Sunapee Lake smelts, even the smallest adult sizes, take a baited hook, suggested that adult smelts, although small, did not feed exclusively upon such fine objects, but fish ranging from a little over 1 inch to a little over 5 inches in length, taken in Sunapee Lake, were found to subsist largely upon *Entomostraca*, although some insects were found and in two instances smelt eggs. The latter are referred to on another page. As was to be expected, the fish taken at spawning time did not contain so much food as later in the season.

Every spring after the ice leaves the lake and the freshets in the brooks have subsided the smelts usually begin to ascend the streams to spawn. The "run" is as a rule by night, although on exceptionally dark days a "run" of smelts has been known to occur. They ascend the streams to various distances from the mouth, and the spawn is deposited upon and adheres to stones, sand, moss, sticks or any other object with which it comes in contact. As before stated, the large smelts, where the "two sizes" exist, run first, and in lakes there the sizes vary, but have no distinct line of demarcation, the larger ones are said to run first and usually the majority of the first runs are males.

The male fish is easily distinguished from the female even in the dark, by touch, when first removed from the water, being profusely covered with tiny tubercles, which feel much like fine sand.

In 1910 the first run of smelts occurred in Pike Brook on the night of April 13. The runs continued to increase in numbers of fish until the 19th, on which night the smelts fairly swarmed in the brook. The runs continued constantly large until the 25th, when they rapidly decreased in numbers until the night of April 30, when only a few stragglers were observed in the brook. After April 21 those remaining in the pools decreased in numbers. For sometime, however, the brook was so high and roily that had there been smelts there they could not have been seen. Subsequently the only smelts observed during the daytime were not over a dozen in each of the two pools mentioned on the 22d and 23d, only one smelt on the 24th, and a small school in the hatchery pool on the 25th.

It has been generally supposed that smelts invariably return to the lake on the night of their ascent, after spawning. The writer's observations on the marine smelt in small coastwise brooks revealed that, when undisturbed during the night, large numbers, if not all, remained in the brook the next day, and often some smelts lingered in the brooks long after the spawning season was over, becoming emaciated and weak. Those remaining after the spawning season, so far as examined, always proved to be males. These facts led to the suspicion that possibly fresh-water smelts might have a similar habit; and at Sunapee Lake it was found to be a fact that if the smelts were undisturbed during the night before, the next day large numbers were found along Pike Brook as far up as they could ascend, but mostly congregated in the deeper pools. On April 16, 1910, notwithstanding the fact that there was some "dipping" during the first of the night before at the mouth of the brook, schools of smelts were found all along the brook, from just below the hatchery up 200 or 300 yards, in every little pool, and the same conditions obtained on the 17th. On the 20th smelts were observed in the pools, but there were not as many as could have been expected from the run of the night before. After the 20th no large numbers were observed during the day, but groups of a few or individuals here and there were sometimes seen.

It was observed that they, sometimes at least, begin to feed before descending to the lake. On April 20, in a large deep pool, some smelts appeared to be feeding, moving moderately here and there as though picking up or looking for something floating in the water. In the afternoon the writer, using a tiny hook with a small piece of earthworm for bait, caught six of the smelts, which proved to be spent or partly spent males, still having rather large milts. Two were 4, one 4¼, two 4½, and one 4⅝ inches in length. There were many more bites, but the fish could not be hooked. Some of the fish would come up to the bait slowly, open their mouths and take it in; some would dart at it quite smartly; some would not notice it unless it were moving rapidly; and some would pay no attention to it whatever. The latter were the larger smelts. The stomachs of three of the larger fish caught contained smelt eggs and several insect larvæ, apparently mosquito.

The spawning period varies from three to six weeks at Sunapee, lasting on an average not over a month at most. The runs gradually increase in numbers of smelts to the height or middle of the season, then rapidly decrease in number of individuals. No smelts were actually seen leaving the brooks until April 18, when some were reported to be drifting tail first out of the mouth of King Hill Brook at 8.30 p. m. It is possible that they were really an in-run that settled back toward the lake upon the approach of the observer. On April 24, well up Pike Brook, at 9.30 p. m., a good many smelts were evidently running downstream head first, but at the mouth smelts were streaming in in large numbers. At no other times, however, were any seen actually descending the brook, although a decreasing number was observed in the brook each successive day until May 1. But there was plenty of time in which they could have migrated unobserved.

After the spawning period for some days, even weeks, many dead and dying smelts are found at the surface and washed on the beach, bearing no lesions or marks of injury. It was formerly thought that perhaps it was due to the exhaustion and starvation of the spawning period, which causes them to succumb to slight changes of temperature, or inability to obtain sufficient food soon enough to enable them to recuperate. But throughout the season more or less dead of various sizes and ages are found washed up on the beaches. At Sunapee Lake some dead and dying adult fish, ranging in length from 3½ to 7 inches, were observed near the mouths of brooks during the spawning season. Such fish, however, did not occur there in such large numbers as have been observed in other waters during and following the spawning, and young and adults were found throughout the seasons of 1910 and 1911.

Seldom were any lesions observable and those at any time present were usually a congestion about the vent, which was occasionally accompanied by a growth of fungus in the same place. This condition was rendered insignificant as a result of the spawning function alone, as a number were found in October in a like condition. That the death at spawning time was only coincident was indicated by the finding of several of them that were not quite ripe and some ripe fish that had not been into the brooks; and young or yearling fish, 2½ to 3 inches long, were also found at the beginning of the spawning season.

A few instances of dead fish that had evidently been in the brook were noted. They were spent, and their stomachs contained smelt eggs besides insects. This fact indicates that the death, even at spawning time, perhaps could not be ascribed to weakness from starvation, especially when the dead and dying fish that had not entered the brook were found to contain some food.

The dead and dying fish picked up on the beaches were more numerous during the spring and fall than in the summer. This may be due to the fact that smelts reside mostly in deep water during the warmer months, and though they die in those months they would be quickly snapped up by trout and salmon. It may indicate that in the fall, as the water becomes cooler, the fish approach the surface and perhaps the shore, as indicated by the presence of insects in the stomachs of those examined.

The presence of dead smelts along the beaches could not be connected with any sudden change of temperature, although they usually and most abundantly appeared during or shortly after strong winds. The latter probably accounts only for their being washed up, although possibly smelts swimming in shallow water might be washed up and thus killed by the heavy seas raised by the strong winds. But this would not account for those found when there had been no strong winds. Intestinal parasites were found in many but not all of the October smelts examined, but this partial freedom from parasites seems to eliminate them as a factor in the mortality.

Therefore, the cause of death of so many smelts throughout the season is as yet unsolved. After all, those found dead on the shores or floating at the surface are few compared with the multitudes that live in the lake, and it is perhaps quite natural that there should be deaths due to obscure causes, as among higher animals.

Efforts were made night and day to ascertain if there were any peculiar habits or movements connected with the spawning. The following is a detailed account of the observations made:

The first observations were made on the night of April 15, 1910, when smelts were found making their way some distance above the mouth of the brook at the outer edge of the beach. After reaching the head of the channel they seemed to have some hesitation about entering the dead water above, swimming back for a short distance several times before going in. But this action may have been due wholly or in part to the lantern or the writer standing near the place. Whenever startled by anyone approaching the brook they would run down a short distance, but when "dipped" at with nets they strove to get upstream even in the face of much splashing of the water with the feet while standing in the brook.

During the day of April 16, in one pool the smelts occupied an eddy between two currents, circling about in the eddy, but not heading in definite order, sometimes downstream, sometimes up, and sometimes crosswise, and often some heading in one direction and some in another. In another pool above this a school occupied an eddy, swimming about irregularly and slowly to some extent, and generally rather stationary or drifting irregularly, but with their heads generally toward the slow return current at almost right angles to the bank.

In another pool a school started by the writer's step on the bank darted downstream as far as a shoal ripple, then slowly returned with heads all directed upstream, some smelts above others, but all in the same direction. The smelts when undisturbed did not all occupy the same level in the water; some were near bottom and some farther up in the water, even at times near the surface, but they were all the time rising and settling again, swimming back and forth individually and to some extent collectively but irregularly in the latter case. There was no evidence that they were at this time spawning. In the first pool mentioned a few eggs were seen attached to dead leaves, moss, and sticks, but they were white and may have been extruded when the fish were disturbed the previous night by dipping. Further observations show that the smelts very slowly moved about in the eddy in a comparatively large "circle" or rather ellipse, but in a very irregular manner.

Two smelts, one large and the other small, were seen to come rather quickly to the surface together, breaking water with their backs. Probably this was not significant, as no more were seen to do it, or anything like it, during a long watch. No evidence of pairing was observed.

Later in another place a small school of smelts was seen lying at the foot of a pool in which was considerable current. They were comparatively motionless, just above a shallow ripple, heads all upstream, merely drifting from side to side, when with one or two quick flirts of the tail they kept themselves from going backward. They scarcely moved upstream at all at any time, and when there was such a movement it was only on the part of one or two of them, not the whole school.

At 9 p. m. the smelts had mostly gone out of the deep holes and were scattered along the brook, generally on the ripples, but on the morning of April 17 the schools were all in the deep holes where they were seen during the day before.

On the night of April 18 the writer observed some smelts in the brook by the hatchery that were evidently spawning, making no attempt to go farther up the brook. There were, however, others above and some running up by them. Those watched were in shallow water on sand, fine gravel, and pebbles and headed upstream where the current ran quickest, but nearer shore they would lie on the bottom with their heads in no particular direction. Sometimes they were so near shore that their backs were nearly out of water. There were some rather quick movements made by those in quick water, but evidently for the purpose of maintaining their position where they were swinging from side to side but not going forward, sometimes, however, turning and running down or to one side a short distance. But those in the still water lay comparatively quiet, some of them actually resting on the bottom, but they all moved about to a slight degree.

On the night of April 19 further observations were made on the smelts that fairly swarmed in Pike Brook. They did not seem to be disturbed by lantern light but, of course, it is possible that their movements may have been more or less modified by it. No very peculiar movements were observed. There appeared to be no pairing, each fish lying by itself, quietly on the bottom, slightly on its side in a sort of curve. Sometimes one would lie near another and occasionally one would dart forward under the edge of a partly submerged sod.

During the day of the 20th the smelts were all in pools, usually stationary with heads pointed upstream, occasionally swimming a little and now and then turning to one side or downstream.

During the day of the 22d a fair-sized school was seen in the pool by the hatchery, but there was none in the deep pool where they were caught with hook. There were three or four "scattering" smelts in other places. In the night the fish were scattered mostly in shallow and quick water. Some that were probably spawning were observed. There was one group of 8 or 10 or more individuals side by side and before and behind, in rather quick water, neither going forward or backward, but swinging back and forth with the current like a bunch of moss, those ahead with a slighter motion than those farther behind. A few others in pairs, or single, were in stiller, shallow water apparently spawning, moving about slightly but usually with head upstream. There was some current here. They seemed to some extent to lie on their sides, and they moved up into shallower water until their noses were out of water on the gravel. One fish got on top of a stone with half of its body out of water and stayed there some time without seeming to mind it. There seemed to be no contact of bodies except apparently accidentally or incident to the swinging or waving in the current. On the other side of the brook on a rather steep slope of sand and clay bank in shallow water, quite a number were seen likewise stationary. Their movements were similar to the others just previously mentioned. No lantern was used in watching the first two lots mentioned. While the smelts mentioned remained stationary, many others were shooting up, over, and among them on their way up the brook.

There was a good run on April 23. At 8 p. m. some up under the overhanging bank on a steep shelving bottom were watched. Their heads were upstream and they were swinging or waving from side to side, their bodies occasionally, perhaps, brushing against a neighbor, but no other contact was noticed and apparently no pairing or any approach to it took place.

The smelts constituting the run of the night of April 13 were said to be "large" fish, but most of those of April 15, as shown by measurement of over 100, ranged from 4¼ to 5 inches, and there was only one of the latter length. Those taken on the night of April 17 ranged from 4¼ to 8½, although the majority were from 4¼ to 5 inches in length. While the larger fish were always present, the proportion was somewhat smaller toward the last of the season. This, taken with the fact that in the first runs male fish predominate, was thought to indicate that the male averages somewhat larger than the female, although occasionally a female as long as 8½ inches was observed. The following table shows that males continue to predominate during their breeding season and that the smallest fish caught was a male and the largest a female.

TABLE SHOWING PROPORTION OF MALE AND FEMALE SMELTS AND RANGE IN SIZE OF EACH SEX.

Date.	Total examined.	Males.	Females.	Size of males.	Size of females.
				Inches.	*Inches.*
Apr. 18	493	465	28	4 -7	4 -7
18	871	771	100	4 -7	4 -8½
19	1,336	1,000	336	3½-7½	4 -8
24	213	186	27	3[illegible]-5[illegible]	3½-4[illegible]

The smelt is very prolific, an individual 4⅝ inches long carrying 5,893 eggs, as ascertained by actual count. Doubtless some eggs escape fertilization, but the countless numbers of "eyed eggs" observed clinging to moss indicated that the yield of the spring of 1910 in Pike Brook alone would be a large one. The period of incubation appears to be short, the eggs hatching in from 10 to 15 days, according to the temperature of the water. The young are tender, threadlike creatures, but grow rapidly and enter the lake at an early age.

Enemies.—The smelt is not free from enemies even in the brook, where large predaceous fishes can not enter, but there, aside from man, by far the most destructive are minks, sheldrakes, kingfishers, trout, and chubs, all of which were at times observed at Pike Brook in April, 1910. The birds and minks take the adult smelt, as does the trout to some extent, but the trout and chub feed mainly upon the eggs and young, and, as has been shown, the smelt is not averse to its own eggs.

The smelt is a delicious pan fish and even the smallest fried whole, in the manner of whitebait, are highly esteemed. It is the natural food of the landlocked salmon, and the salmon thrives only where there are smelts.

Effects upon fishing for other fish.—It has been claimed that where smelts abound the fishing is greatly interfered with; the fish will not take the fly and rarely any other bait than live smelt.

In a letter received by Mr. John W. Titcomb, then fish commissioner of Vermont, and published in Forest and Stream of June 27, 1896, the poor fishing of the preceding May at Sunapee Lake was ascribed to the smelt. Among other things the letter stated that where smelts occur a piece of maple sugar for bait would be almost as effective as any fish other than smelt, and goes on to say:

> There is no doubt but that the smelt is great food, but if it spoils the fishing with rod and tackle, where is its advantage? It certainly may ruin the fly fishing, as it no doubt does the bait fishing, to a very great extent. There is no fly fishing at Sunapee at all and the only way that it is accounted for there is the smelt.

Mr. Titcomb, commenting on the statement, wrote:

> It would be unreasonable to think of depriving a body of water of desirable fish food for the purpose of forcing a fish to rise to the surface to take flies or other artificial bait.

This is a very pertinent remark, for where there is not sufficient food the fish can hardly attain a size to make them worth catching. On another page it has been stated that where insects afford the only food supply trout do not grow very large.

It seems to be a peculiar trait of the mind of man, or at least of the minds of some men, to account for phenomena by the most prominent or conspicuous condition that may be a possible cause. In other words they jump at conclusions without sufficient verification.

If in any lake the water is high or low and the fishing good or poor, it is good or poor because the water is high or low, as the case may be. Good fishing or poor fishing in a lake abounding in or free from smelts is ascribed to the abundance or lack of food supply, and those persons have in mind the one body of water and the immediate conditions obtaining there to base their conclusions upon.

Smelts abound in Sebago Lake, Me., and they are apparently just as abundant one year as another, but the fishing varies; one year or at one portion of the season the fishing is good, at another bad. Which is the smelt accountable for? In Sunapee Lake also there have been seasons of good fishing, notwithstanding the smelts, and there were times of poor fishing before Sunapee knew the smelt, if the reports of the State commissioners can be trusted.

As for fly fishing being ruined by the abundance of smelts or other food supply, other waters where the smelts abound and where fly fishing is unexcelled need only be cited to controvert the contention. One of these is Grand Lake, in the western St. Croix waters. In any body of water one principal reason that fish are not taken on the fly is that they are not fished for with the fly. Notwithstanding the prevalent opinion that salmon never take the fly in Sebago Lake owing to the smelt, whenever anyone has persistently fished with a fly salmon have been caught by that means, and one usually has to persistently fish by any method to land many fish. Furthermore, the writer has examined hundreds of Sebago salmon, and while the majority, when they contained any food at all, have smelt in their stomach, many have been found having insects only, and some containing both insects and smelts or some other fish.

These remarks apply mainly to the landlocked salmon and it may be added that the writer has still-fished for smelts and salmon on the same "ground" and used live smelt, live shiners, and pieces of smelt for bait for salmon, and has caught just as many on shiners as on smelt and nearly as many on the cut bait as on the live bait. The scarcity of "native trout" in Sunapee easily accounts for the poor fishing with bait or fly.

While the white trout has been taken on the fly, it is primarily a deep-water fish and is taken mainly by bait. But in the way of bait it does not seem to prefer smelts to some other bait. In Floods Pond in Maine, where there are plenty of smelts, a small piece of fresh uncooked lobster is an unexcelled bait.

Apropos the scarcity of native trout and the growing scarcity of white trout, it might be well to say that which is suggested elsewhere in this report, that had not Dr. Fletcher in his (or some one's else) wisdom planted smelts in Sunapee Lake, the trout would have disappeared before the salmon long ago, and the salmon would not have lasted as long as they have.

Smelts were first introduced into Sunapee Lake by Dr. Fletcher in the spring of 1870. These, 700 in all, were obtained in Winnepesaukee or a tributary lake. Another plant of 1,000 was made in 1872, but it is not stated from what water they were obtained. The New Hampshire Fish Commissioner's report for this year states that several smelts were caught that spring in a brook running into Sunapee Lake, where they were introduced two years before, and in the report for 1873 it is said that smelts were seen in the streams running into the same lake, "attending to their propagating duties." In two years the smelts manifested themselves in the brooks and the next year were there in apparently increased numbers. In 40 years they fairly swarmed in the lake; in fact, they have abounded there for years. While the adult smelt easily succumbs, its eggs are hardy, especially after they are "eyed," and may, with reasonable care, be transported long distances.

SUNFISH (*Lepomis auritus*).

This is the fish commonly referred to at Sunapee Lake as "pumpkin seed," and it seems to be very abundant, though not attaining so large a size as it does in some waters. In its young stages it is to some extent eaten by black bass and other fishes occurring in the same localities with sunfish. In its adult size it is more or less destructive of other fishes, especially the young, occurring in the same localities, but it is mainly an insect feeder, and for that reason does little harm.

In some parts of the country large sunfish of this species are considered as food fish, but owing to their small size in Sunapee Lake they are not often used for that purpose.

Throughout the summer and fall hundreds of various sizes could be seen about the steamer wharf at Blodgetts Landing, in company with some small black bass.

PUMPKIN SEED (*Lepomis gibbosus*).

The fish was not observed by the writer in any of the Sunapee waters. It is included in the list on the authority of Hon. Nathaniel Wentworth, who says it occurs in Sunapee Lake.

This species is more properly the pumpkin seed than the preceding. It may be distinguished from the other by its always shorter and red-margined black gill flap, smaller mouth, and 4 rows of scales on the cheeks instead of 7 as in the other.

BLACK BASS (*Micropterus dolomieu*).

The black bass is a member of the sunfish family to which the previously mentioned sunfish and pumpkin seed belong. It is therefore not a bass. The only importance attached to this fact, so far as Sunapee Lake and its fish and fishing are concerned, is that it accordingly has not the habits of a bass. True basses are voracious, marauding, devastating pirates. The white perch is one of them. The black bass, however, is a comparatively inoffensive citizen. It has its faults, and chief of these is that it sometimes, not infrequently, eats other fishes, but as will appear from quotations given later in this paper, this fault is sometimes a commendable one. The natural range of this species is given in the books as "from Lake Champlain to Manitoba and southward on both sides of the mountains from James River to South Carolina and Arkansas." It is justly held in high esteem by all anglers as a game fish and, with some exceptions, as a food fish.

Dr. James A. Henshall, the noted champion of the black bass, says of it:

> The black bass is eminently an American fish; he has the faculty of asserting himself and of making himself completely at home wherever placed. He is plucky, game,

> brave, unyielding to the last, when hooked. He has the arrowy rush and vigor of a trout, the untiring strength and bold leap of a salmon, while he has a system of fighting tactics peculiarly his own. I consider him, inch for inch and pound for pound, the gamest fish that swims.

It is unnecessary to say anything more on these points. Every angler has views of his own regarding his favorite fish, and nothing can be said or written that will change his opinion.

Young bass subsist chiefly upon minute Crustacea and insects, and as they increase in size and age they feed upon worms, tadpoles, small fish, etc., and, as Dr. Henshall says, "In later life they vary their diet with crawfish, frogs, mussels, and water snakes, until, attaining a weight of 2 pounds, they will bolt anything from an angle worm to a young muskrat."

Under favorable conditions the black bass grows rapidly and in some waters has been known to attain a weight of 8 pounds and over. It also rapidly multiplies, so that in a few years, when suitable conditions exist, those waters into which it has been introduced have usually been completely stocked.

What effect the introduction and multiplication of the black bass in Sunapee Lake has had on the fishes and conditions of that lake is hard to say without knowing more definitely what the conditions were at and prior to the introduction.

The following quotations indicate that it has been a destructive agency at least so far as perch are concerned, and if destructive to perch why not other fishes as easily obtained?

The first black bass to be placed in Sunapee Lake were brought from Lake Champlain in 1867 or 1868. The State fish and game report for 1871 (June session) states that in the past year large numbers of young bass have been observed and many have been caught while fishing for other fish. It goes on to say that the people in that vicinity appear quite anxious to have the lake well stocked with bass.

The State report for 1872 states that many bass have been caught in Sunapee Lake.

The State report for 1873 says black bass are reported to be very numerous in Sunapee.

The report for 1874 says:

> We found the bass quite plenty in Sunapee Lake last summer, and succeeded in catching over 400 with hook and lines for stocking purposes.

After speaking of the fish in other waters, the report for 1876 says:

> But Lake Sunapee bears away the palm, its waters literally teeming with bass and affording splendid sport to the angler. As a hint toward their wonderful increase and abundance there, it may be stated that, stocked in 1868, in the season of 1875 it is estimated that 3 tons of black bass were taken from the lake.

On another page it states that in the first of the winter a black bass weighing over 4 pounds was caught through the ice.

The report of 1879 seems to indicate a revulsion of the former enthusiasm over the black bass. It says:

> There is a very strong feeling in many parts of the State that our labors had better be confined to increasing our stock of native fish and restoring those once common to our waters, rather than to introduce new varieties of scaly foreigners who may do more harm than good. Black bass have only been partially a success, and from their rapid spread in the Merrimack and Connecticut Rivers may prove to be very detrimental to our efforts to restock those rivers with salmon and shad.

The report for 1881 says:

> One of your commissioners, in going by Sunapee Lake last summer, on his way to Clairmont, at 5 o'clock p. m. saw a string of 47 pounds' weight put on the train by two gentlemen who had arrived there at 10 o'clock the same morning.

In the report of 1888 the commissioner shows cause why the black bass is a blessing to Sunapee Lake, in the following words:

> Here I wish to say a word in favor of the much-abused and misunderstood black bass. Previous to the introduction of the black bass into Sunapee Lake it was not known as a trout lake except to a few in its immediate vicinity, and the catch of trout, with the exception of those netted and speared during the spawning season, was very small. The lake at that time was infested with large numbers of small yellow perch, which destroyed the young trout as soon as hatched. Especially is this true of the *Aureolus*, they being lake spawners. The black bass have destroyed the perch, and their place is now taken by hundreds of the finest trout in the world. Here we have a lake noted for its excellent bass fishing, and at the same time one of the finest trout and salmon lakes in New England, and no fisherman on the lake has ever made complaint that the bass interfered with the trout in any way.

But again, in the report for 1900 (1901), the commissioners (different ones) say:

> The bass have become so numerous in Sunapee Lake as to satisfy us, if not all, that protection should be taken from them for a time in those waters, and fishermen should be allowed to take them at all times, and of any size, until their numbers are so far reduced as to secure the comparative safety of other fish from their ravages.
>
> A year ago last August, Commissioners Wentworth and Shurtlef spent two days at Sunapee experimenting on bass, and during that time we caught in deep water 8 to 10 bass, from the stomachs of which we took *Aureolus*, or white trout, and brook trout, which was to us an easy solution of the question which has been often asked, Why are there no more small brook trout in Sunapee?

In the report for 1889 the statement is made that "black-bass fishing was better in 1888 than it had been for a number of years."

In the report for 1904, after stating that in Sunapee Lake more large salmon were taken the last year than in any one year for 20 years, they continue:

> In the last 12 years our commission has never planted black bass in waters that contained salmon or trout. There is no doubt that in Sunapee Lake, where they are very plenty, they have done much to retard the increase of both trout and salmon.

Lately the conviction seems to prevail among black-bass anglers that the fish is not only growing much scarcer, but that it seldom attains the size that it formerly did. The season of 1910 was very poor in numbers and size of those caught. The fishing in 1912 was much better, but far below that of former years. Others maintained that the black bass was just as abundant and as unmitigated a nuisance as it ever was.

It is undoubtedly true that it is only occasionally that good catches of sizable bass are made, and that it is, as a rule, only by persistent fishing that satisfactory strings of fish of legal size can be taken. Notwithstanding this fact, young black bass up to a few inches in length seem to be fairly common. During August and October of 1910 and July and August of 1911 young from 2 up to 10 inches in length were observed in considerable numbers in places about the shores, especially at the steamboat pier at Blodgetts Landing.

In 1911 the largest fish observed by the writer was estimated to weigh 4 pounds and was one of a catch of 17 fish that perhaps would run from 2 to 3 pounds each.

It is also stated that while years ago the fly fishing for black bass was unexcelled anywhere, the fish no longer can be caught on a fly, due to its having resorted to the deep waters, where it subsists upon smelts and other fishes occurring there. This idea arises from the fact that smelts are occasionally found in the stomachs of black bass and that the fish is sometimes caught at the deep-water fishing places. Of course, it is obviously unnecessary for black bass to go into deep water for an occasional smelt. In August, 1910, several instances of black bass at The Hedgehog fishing "grounds" were noted. Some were seen at not a great depth below the surface and others were caught there on short lines, but at no time was one known to be taken at the bottom. It was quite evident, at least, that the supposed deep-water bass were not at the bottom, and their stomach contents consisting wholly of insects, when there were any contents, supported the evidence. However, the possibility of black bass occasionally resorting to the greater depths is not disputed.

While the capture of a few small black bass (about 10 inches in length) on The Reef in gill nets by the white-trout spawn takers gave rise to suspicion that this fish might include spawn eating in its category of harmful traits, the empty stomachs of these specimens were circumstantial evidence in its favor.

That black bass will and do eat other fishes is undoubted. They have been known to eat young perch, as has been pointed out in the quotations, and the writer's notes show that they also have eaten shiners, chubs, young catfish (horn pouts), sunfish, black bass, pickerel, and smelts. But at Sunapee Lake during August, 1910, and July, 1911, both adult and young were found to subsist mainly upon insects and aquatic larvæ of insects. Perch are stated to have once abounded in the lake; chubs usually abound in such favorable waters when their enemies do not preponderate; and pickerel were formerly common. It may be inferred, therefore, that black bass have been a factor in producing their scarcity. In the case of the perch and the pickerel the bass may have worked two ways: One by devouring the fish themselves and the other by eating their food. It is probable that when chubs were abundant they contributed a great deal to the food supply of perch and pickerel. Being deprived of this food, they were driven to other scarcer food, or to food obtainable with greater difficulty, which would tend toward their diminution in numbers.

Then there is the indirect effect on other fishes to be considered, as well as the direct effect on some of them. Pickerel and perch, for instance, driven to other food, would eat more of other fishes that they did not previously attack so extensively, or else they would deprive other fishes of food perhaps already scarce. Thus it may be seen that the direct and indirect effects of introducing nonindigenous fishes may be far reaching, as has already been pointed out.

As already suggested, it is impossible to state definitely the effects of the introduction of the fish. But it has been shown that certain fishes have almost completely disappeared, or have become very scarce as the black bass increase in numbers and size. But there is another thing that almost inevitably occurs in such instances. The fact that a fish exterminates any other fish indicates that the particular exterminated form was the most sought or the only one available. This food being exhausted, it has to resort to other forms which are not so easily obtainable and to feeding upon its own young, with the consequences that the introduced fish decreases in size and diminishes in numbers. Judging from the foregoing reports of the former abundance and size of black bass and the present comparative scarcity and decreased size, it would appear that something like this has happened to the black bass of Sunapee Lake.

PIKE PERCH (*Stizostedion vitreum*).

The pike perch is variously known in different localities as walleyed pike, pike perch, dore, grass eye, yellow pike, blue pike, jack salmon, salmon, white-eye, pike, and pickerel. It is a member of the perch family along with the yellow perch. Its natural geographical range is the Great Lakes region, upper Mississippi, north to Assiniboia and Hudson Bay region, east to Vermont and Pennsylvania, and south to Georgia and Alabama. It is by far the largest species of the family and the most important commercially. It attains as high as 20 pounds weight.

It is a voracious, carnivorous fish, residing in the colder waters of the lake or river that it inhabits, for which reason its successful acclimatization in Sunapee Lake would have been deplorable, as it there would have inhabited the same waters with trout and salmon.

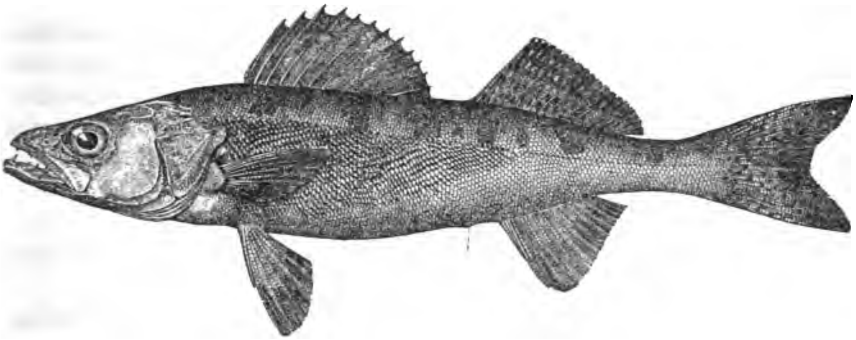


FIG. 4.—Pike perch.

The State Fish and Game Report for 1876 says:

> In May fish were procured from Alburg, Lake Champlain, and some of them planted in Sunapee Lake, probably the waters most suitable to successful fish propagation in our State.

Nothing further has been reported regarding this plant, and upon the whole it is undoubtedly fortunate that this is so.

PERCH (*Perca flavescens*).

The perch is a common fish in most New England fresh waters, and in many places it fairly swarms. It is carnivorous and almost omnivorous in that direction. It subsists mainly, however, upon small fishes and insects and is very destructive to young fishes and fish eggs.

The perch reaches a weight of at least 2 pounds in some waters, but as most commonly known averages not over one-half pound as a hook-and-line fish. It is a delectable pan fish, notwithstanding prejudices based upon fallacious or mistaken reasons entertained toward it. While its young afford food for other species of fish as well as itself, it in turn devours the young of others. The perch seems to have been indigenous to Sunapee Lake and at one time to have abounded there, as indicated in this paper by reference to it in connection with the black bass.

Wherever the perch abound the young are always conspicuously manifest about the shores and in shallow water, especially along beaches. But in the two seasons that the Bureau of Fisheries party made observations at Sunapee not a single young yellow perch was seen, and the only adult seen was one 12 inches long found dead at the surface on July 28, 1911, below the narrows. It showed no indication of having been hooked and there were no other lesions to which its death could be ascribed. The blame for its scarcity in Sunapee Lake, as has been seen in the discussion of the black bass, is laid to the door of that fish, but there are instances of the complete extinction of perch in ponds where there were no black bass or other large fish to devour them. This is presumably due to some epidemic or cataclysm that destroyed them. A fact that would seem to weaken the contention that the black bass is responsible for the disappearance of perch is the fact that there are ponds where both species still exist in undiminished numbers. But that may be accounted for by assuming the presence of other food better suited to the taste of the black bass.

BATRACHIANS.

The following observations were made upon the frogs, toads, and salamanders of Sunapee Lake and vicinity:

Hyla versicolor (tree toads) were found in large numbers, breeding, April 15, 1910.

Hyla pickeringii (tree toads) were heard "calling" on April 22.

Rana catesbiana (bullfrog); one individual was seen in King Hill Brook April 22.

Rana clamatans (green frog) was seen August 12 in Blodgetts Brook.

Rana sp. (tadpoles) in large numbers were observed in a pool near the mouth of Blodgetts Brook, October 20.

Bufo americanus (common toad); many were heard calling on April 22, 1910, and one was caught in a fyke net at the head of Pike Brook dead water, August 16, 1911.

Diemyctelus viridescens (water newt). The red or so-called land form (*D. miniatus*) was found among the alders bordering Pike Brook, April 20, 1910. In shallow water at Soo-nipi Park beach one "heavy" with eggs was found, and in Pike Brook a male was taken on April 23; also one in King Hill Brook August 25. A number were caught in a fyke net set in Pike Brook outlet through the beach, August 17, 1911.

Spelerpes (?) sp. ("evets"). These salamanders were quite numerous in Blodgetts Brook. They are used for black-bass bait.

MOLLUSKS.

The mollusks collected at Sunapee Lake have been identified by Dr. W. H. Dall, curator of mollusks, United States National Museum.

Lampsilus complanatus ("clam") was caught on a troll hook, April 22, 1910; many specimens were gathered in shallow water along the sand beach on the south side of Blodgetts Cove. One of a "swollen" shape was found near the mouth of Blodgetts Brook left by the drying up of the brook, October 20. The species was common everywhere on sandy shoals.

Planorbis bicarinatus. Large numbers were found washed up in "windrows" on the beach at Soo-nipi Park, October 15. Dr. Dall pronounced them very large and fine specimens. This gastropod is evidently abundant in the lake, especially on sandy shoals among the *Chara.*

Campeloma decisa ("snails"). A few specimens were found with *Planorbis* on the beach.

Physa heterostropha ("snails"). A few were found with the preceding and many were collected in a pool near the mouth of Blodgetts Brook, October 20.

SUMMARY AND CONCLUSIONS.[a]

INDIGENOUS FISHES.

There seems to be very little that can be learned regarding the conditions of Sunapee Lake and its fish fauna prior to the beginning of fish culture. But such evidence as there is indicates that the original fauna, with perhaps the addition of the smelt, was the one to which the lake was best adapted.

Native trout.—Tradition indicates that this species once abounded and attained a large size, and the present conditions indicate that the lake was well adapted to the fish. The abundance of smelts has increased its food supply, but, notwithstanding this, it has decreased in size and numbers almost to extinction. The decrease in numbers is believed to be due to lack of early protection and inadequate propagation and to destruction by landlocked salmon. Of the conditions favorable to trout, about all that remains is the food supply.

White trout.—In view of all the known facts, it may be concluded that the white trout was indigenous to Sunapee Lake and the probabilities are that it was once small and inconspicuous from its size and habits.

The first knowledge of the white trout dates from its discovery spawning on the reef, when the fish ran very large. In the matter of time in which to grow, comparing the time of discovery and the date of the introduction of smelts into the lake with the discovery of the first blueback of large size and the date of the introduction of smelts into Rangeley Lakes, all is greatly in favor of the white trout. If the foregoing hypothesis is true, the present size of the white trout is due to abundance of food, and the food still abounds. So far, then, as breeding and feeding conditions alone are concerned, the lake is as favorable as ever for the existence of the white trout.

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[a] The request that the Bureau of Fisheries make a study of the biological and physical conditions of Sunapee Lake, in order that it might intelligently advise how to improve and maintain the fishing, originated with the Sunapee Lake Fishing Association, whose members are conscientiously desirous of improving and maintaining the fishing and are making every active and financial effort to accomplish those results. It is therefore hoped that the suggestions and recommendations herewith offered may assist to that end. The writer recognizes that his views are not infallible and may prove erroneous, but based as they are upon two seasons' observations at Sunapee Lake, all the literature obtainable regarding those waters, and many years of general experience, he can not help feeling that at least some of his opinions are well founded. He wishes to state that he alone is personally responsible for them, and no one else connected with the Bureau of Fisheries necessarily indorses them.

The other indigenous species are either too scarce or too unimportant to merit further discussion than has already been given them in the foregoing report.

INTRODUCED FISHES.

The dangers to indigenous forms by introducing alien predatory fishes into any lake have been discussed, and have to some extent, perhaps, been exemplified in Sunapee Lake, especially with the salmon. By the advent of the chinook, unless checked, these dangers bid fair to be still further demonstrated, modified more or less by the abundance of smelt food at present.

Of the introduced species only the smelt, black bass, landlocked salmon, and chinook have manifested themselves in sufficient numbers to produce any appreciable effect on the conditions and fauna of the lake.

Smelt.—The smelt has been the savior of the salmonids that still exist in the lake, for without the smelt the trout doubtless would have disappeared long ago or the white trout would have continued small and rapidly disappeared before the landlocked salmon and trout combined, as in the case of the blueback at the Rangeleys. The salmon would not have attained the large size that it did. The small salmon would not have yielded so many eggs, and the salmon stock would have more quickly become reduced in numbers.

The smelt evidently does not find sufficient food to cause it to reach the size attained in some lakes. (It is possible, however, that the Sunapee smelt is a different species from the large ones referred to.) But the small size renders it all the more suitable for fish food.

Landlocked salmon.—This fish, once fairly numerous, has greatly decreased in numbers, owing, no doubt, to its inability to find suitable natural breeding places and insufficient fish-cultural attention. So far as the two species of trout are concerned, this is an advantage, but it has been offset by the continued introduction of another salmon.

Chinook.—Sunapee Lake seems peculiarly favorable to some phases of the chinook's existence, principally that of growth. But regarding it enough has already been said to indicate, to the writer's mind at least, that it is uncertain and undesirable. It must be obvious to everyone that an indefinitely continuous supply of chinook eggs from the West can not be depended upon. Therefore, unless the present stock of the lake shows itself self-sustaining, it is a waste of time, money, and fish to continue planting it. For the time will undoubtedly come when the supply of eggs must fail, then if the fish has been continued in the lake at even its present number, the disappearance of the fishes upon which it feeds will have been hastened. When the chinook stock has also gone the lake will be worse off than ever before and there will be some who will call for recommendations as to how to improve and maintain the fishing.[a]

Black bass.—The black bass seems not to reach as large a size as it did in former years or to be so abundant. It has been suggested that the small size is due to a scarcity of the formerly more abundant cyprinid food, and to its habits being such that it seldom, if ever, gets into the deeper waters where the smelt abides. The smelt is occasionally found in the stomach of a black bass, but in such instances probably the smelt was not taken at the bottom. The principal food of the black bass at Sunapee, as has been stated, consists of insects and their aquatic larvæ. It is believed, and so stated by some, that the almost complete disappearance of the perch and scarcity of the pickerel are due to the black bass. This is possibly true, and the small size of the pickerel still remaining may be due indirectly to the same fish. It is doubtless of little or no harm to the salmonids.

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[a] Since this report went to press the Bureau has received a letter from Mr. Ralph S. Davis regarding the status of the chinook in Sunapee Lake in 1913.

Mr. Davis estimates that during the fishing season from 4,000 to 5,000 chinooks, averaging about 3 pounds each, and aggregating at least 6 tons, have been caught. He also cites evidence that some chinooks are spawning naturally in the lake.

By applying the figures given by Mr. Davis to what has been stated in this report it is easily seen that they support the present writer's conclusions, and he would have it understood that the recommendations based upon those conclusions are offered solely because he believes that they indicate the best means of improving and maintaining the fishing in Sunapee Lake.

Mr. Davis's statements, therefore, do not necessitate either a revision or repetition of the arguments presented in this report. A brief summary, however, may be desirable here.

Chinooks have gradually increased in numbers each year and in some instances have reached a fairly large size. The increase has been directly proportional to the number planted in preceding years, and has been manifest only in increased catches by anglers. A few fish approaching maturity and a few in breeding condition have been taken. The scarcity of fish in breeding condition indicates a scarcity of fish to reach that condition, for the fact that some have been caught during the breeding period suggests that inasmuch as special efforts were made to find them, had they been plentiful more would have been taken.

There is no perceptible increase in number of breeding fish, and the average size of fish taken by anglers has decreased.

A few fish reaching breeding condition and reproducing naturally would hardly have an appreciable effect on the maintenance of the stock.

A few only taken and yielding eggs to be hatched artificially and raised to fingerling or older stages would not be sufficient to maintain the stock.

The greater the increase in numbers of fish, the larger the number that will be caught.

If the catches of past years have not left a sufficient number of breeders to replace, by reproduction, those caught, continued plants will probably not do so, without stringent limitations of the catches. But even now 5,000 fish permit of an average of only 1 fish every 4 days to each of 200 anglers in the fishing season of 100 days.

It is doubtful whether a supply from outside sources could be maintained indefinitely.

An increase in number and size of a voracious species signifies an increased amount of food devoured.

To a lake of the size of Sunapee there must be a limit to the number of fish and the food supply, direct and ultimate, that it can support.

The main subsistence of the chinook, as of other salmonids, appears to be the smelt, but it has been shown that the other salmonids may suffer both directly and indirectly from the presence of the chinook. If this is not a certainty, there is still the possibility, amounting almost, if not quite, to a probability.

It would seem, then, that if the foregoing conclusions are correct the longer the plants of chinooks are continued the more certain it is that the future of Sunapee Lake is one of inevitable disaster so far as the Salmonidæ are concerned.

SUGGESTIONS AND RECOMMENDATIONS.

The present conditions of the fish fauna of the lake appear to be a scarcity of everything but smelt, sunfish, black bass, white trout, and perhaps chinook salmon, the latter not very abundant and of only temporary importance. Of the indigenous fishes only the sunfish and white trout are at all common. The sunfish is of little importance and the white trout not abundant. If the smelt alone had been introduced into Sunapee Lake and the propagation of the trout and white trout maintained, the writer is firmly convinced that the lake to-day would abound with those two species. If it were possible to bring the lake back to its pristine condition, the writer would advise that it be done and that the stocking of the lake be begun anew and that no other nonindigenous species than the smelt be admitted to Sunapee waters. If any exception were made it would be in favor of the black bass. As such a reversion can not be accomplished, it only remains to meet the conditions as they are and attempt to solve the problem of stocking and of maintaining the stock in the best way possible in accordance with those conditions.

It has been previously suggested that the original fish fauna, with the addition of the smelt, was the one to which the lake was best adapted. Those conditions have been upset and the question arises, Can they be righted? In order to do that, certain fishes must be got rid of. Can this be done?

The black bass appears to be comparatively harmless so far as the salmonids are concerned, so it may be disregarded.

The landlocked salmon is rapidly vanishing and if allowed to do so will no doubt totally disappear in a few years at the most.

The chinook can not possibly stay if it can not breed naturally there, and if no more are planted the lake will soon be free from it.

Other introduced fish have not appeared at all or in such small numbers as to cause no apprehension and therefore may be disregarded.

The native trout is scarce in the lake, but by persistent and plenteous planting it may increase in numbers and size again as the landlocked salmon and chinook disappear.

The white trout will also increase in numbers and perhaps in size for the same reasons.

Provided they are properly protected, there will thus be saved two of the most attractive native food and game fishes of New England waters.

"*Native*" *and white trout.*—It is recommended, then, that landlocked salmon and the chinook be allowed to go and their departure hastened; that attention be given to the propagation and protection of the trout; that each year as large a number as possible be planted in the best tributary brooks or kept in retaining ponds until large enough to look out for themselves to some extent in the lake. Regarding the selection of brooks, it may be said that the temperature of King Hill Brook usually was from 1° to 2° higher than Pike Brook in the running water and pools in the woods. The spring pools were about the same as in Pike Brook, but the dead water, being more open, was considerably higher than the dead water of Pike Brook.

About the middle of August the woodland portion of Big Brook at Blodgetts gave the same temperature as Pike Brook, i. e., 58°, and Little Brook 2° lower.

The temperature at Sunapee Brook did not vary much from Big Brook at Blodgetts.

From the foregoing data it would seem that Pike Brook is the best brook and, in order, Blodgetts, Sunapee, and King Hill Brooks next. It is suggested that only Pike and Blodgetts Brooks be used, however, and possibly only Pike Brook.

In a few years, doubtless, the lake would furnish its own breeding trout and the expense of buying eggs and young trout would be obviated. The white trout still furnishes its own eggs in sufficient numbers satisfactorily to stock the lake in the absence of the predatory fishes previously mentioned. It has been suggested that the artificial propagation of this species be discontinued and the fish be given a chance to show what it can do unaided. The writer believes it would be unwise to do this, owing to the well-known fact that far more can be hatched artificially than under natural conditions. It is recommended, however, that, if possible, some other method than the one in use to collect breeders be devised and employed.

The brooks used as fish nurseries should be constantly closed and guarded for a number of years at least.

A close season for taking trout of either kind in the lake is recommended, from September 1 to May 1 (or until the ice has broken up in the lake, if preferred). No ice fishing should be permitted. It should be permitted to retain no trout of either species taken in the lake under 12 inches in length. Only single hook should be permitted, whether bait hook, fly, or other artificial lure. This is not intended to exclude two or three "single" hooks on a smelt line or two or three flies on a cast, but to exclude the use of gangs and grapples. An angler ought to be satisfied to fish for trout with one rod and with one hand line for smelts for bait. The practice of setting lines or rods over night from wharves, piers, and the shore or leaving them unattended at any time should be discontinued. The quantity of trout of either or both kinds legally to be taken by one man in one day should not exceed 10 pounds.

Salmon.—The foregoing applies to efforts to revive the native trout fishing and to improve the fishing for white trout, which the writer firmly believes can be done only, as said before, by ridding the lake, or allowing it to rid itself, of the undesirables previously mentioned. If, however, it is insisted that there must be salmon, let it be the landlocked salmon. It is undoubtedly as undesirable as the chinook in its fish-eating propensities and capabilities, and with an extensive cultivation of it in the lake the writer must repeat that he firmly believes both species of trout would eventually become extinct. But the landlocked salmon is superior in many ways to the chinook. It probably will reach as large a size as the chinook in Sunapee Lake; it is a much gamer fish; it bites as readily and it takes the artificial fly, which the chinook does not; it does not necessarily die after spawning, which the chinook always does; it is just as good eating; and a supply of eggs or young is much more easily and cheaply obtained.

Besides all this, Pike Brook and perhaps some others could be made accessible in breeding time and the stock be made again self-sustaining. The brook could be made accessible by digging or dredging through the beach and walling the channel jetty-fashion with logs. When the brook is not too dry this would cause a current that would keep the channel clear of sand. There is, however, usually plenty of water in the fall to permit the ingress of salmon if there were a channel of this kind through the beach.

In the place of gill nets, it is suggested that pounds or traps be set near the mouths of the brooks for the purpose of taking the salmon, as well as the trout, in the breeding season.

Salmon fry or fingerlings could be planted in the brooks. If retained in hatchery pools until a year or more old they could with more safety be placed in the lake. The planting of fry in the brooks in spring is recommended, if it is desired to economize in expenses. It is believed that fry planted in the brooks in the spring would produce better results than larger fish in the fall planted in brooks or lake, owing to the greater abundance of natural food at that time and during the summer. The only objection appears to be the possibility of the brooks drying up to such an extent during the summer as to leave the fish stranded. It is not likely that there will be severer droughts than during 1910 and 1911, and it has been shown that during those two summers there was sufficient water in Pike Brook and Little Brook at Blodgetts. Besides, young salmon will endure higher temperature than trout, and the pools of the meadows are always comparatively deep and not too warm for salmon. It is advised that a close time for landlocked salmon be for the same period as the trout. It is suggested that a salmon 12 inches long is a rather small fish of its kind, and the writer would advise making

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